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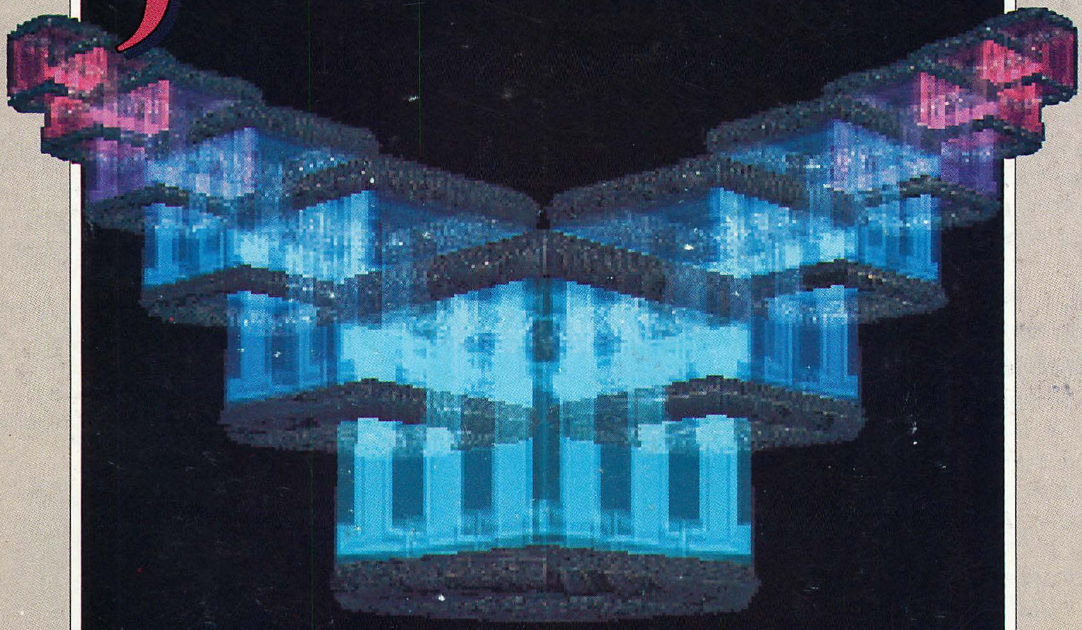

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> **Bruce Webster, BYTE**”

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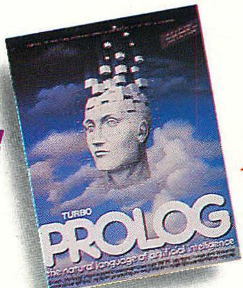

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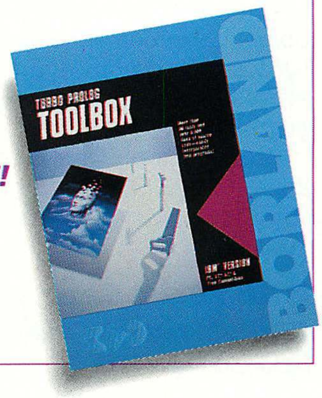

System requirements

Turbo Prolog: IBM PC, XT, AT or true compatibles. PC-DOS (MS-DOS) 2.0 or later. 384K. Turbo Prolog Toolbox requires Turbo Prolog 1.10 or higher. Dual-floppy disk drive or hard disk. 512K.

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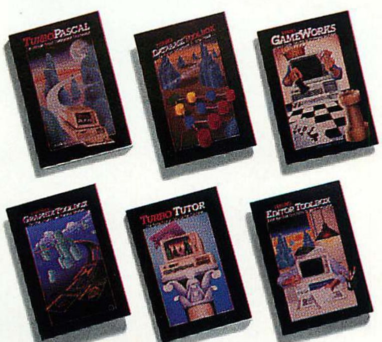

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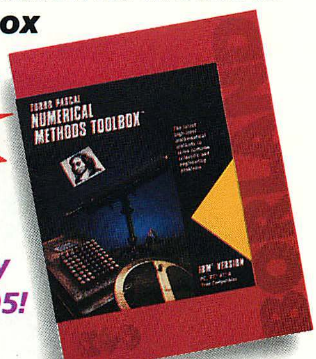

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Borland's Turbo Basic has advantages over the Microsoft product, including support of the high-speed 8087 math chip.

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Free spreadsheet included, complete with source code!

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A technical look at Turbo Basic

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- ☑ *Floating-point support, with full 8087 (math co-processor) integration. Software emulation if no 8087 present*
- ☑ *Program size limited only by available memory (no 64K limitation)*
- ☑ *EGA and CGA support*
- ☑ *Access to local, static, and global variables*
- ☑ *Full integration of the compiler, editor, and executable program, with separate windows for editing, messages, tracing, and execution*
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- ☑ *New long integer (32-bit) data type*
- ☑ *Full 80-bit precision*
- ☑ *Pull-down menus*
- ☑ *Full window management*

System requirements

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System requirements

IBM PC, XT, AT and true compatibles. PC-DOS (MS-DOS) 2.0 or later. One floppy drive. 320K.

Technical Specifications

- Compiler: One-pass compiler generating linkable object modules and inline assembler. Included is Borland's high performance "Turbo Linker." The object module is compatible with the PC-DOS linker. Supports tiny, small, compact, medium, large, and huge memory model libraries. Can mix models with near and far pointers. Includes floating point emulator (utilizes 8087/80287 if installed).
- Interactive Editor: The system includes a powerful, interactive full-screen text editor. If the compiler detects an error, the editor automatically positions the cursor appropriately in the source code.
- Development Environment: A powerful "Make" is included so that managing Turbo C program development is highly efficient. Also includes pull-down menus and windows.
- Links with relocatable object modules created using Borland's Turbo Prolog into a single program.
- ANSI C compatible.
- Start-up routine source code included.
- Both command line and integrated environment versions included.

*Introductory price—good through July 1, 1987

Sieve benchmark (25 iterations)

	Turbo C	Microsoft® C	Lattice C
Compile time	3.89	16.37	13.90
Compile and link time	9.94	29.06	27.79
Execution time	5.77	9.51	13.79
Object code size	274	297	301
Price	$99.95	$450.00	$500.00

Benchmark run on a 6 Mhz IBM AT using Turbo C version 1.0 and the Turbo Linker version 1.0; Microsoft C version 4.0 and the MS overlay linker version 3.51; Lattice C version 3.1 and the MS object linker version 3.05.

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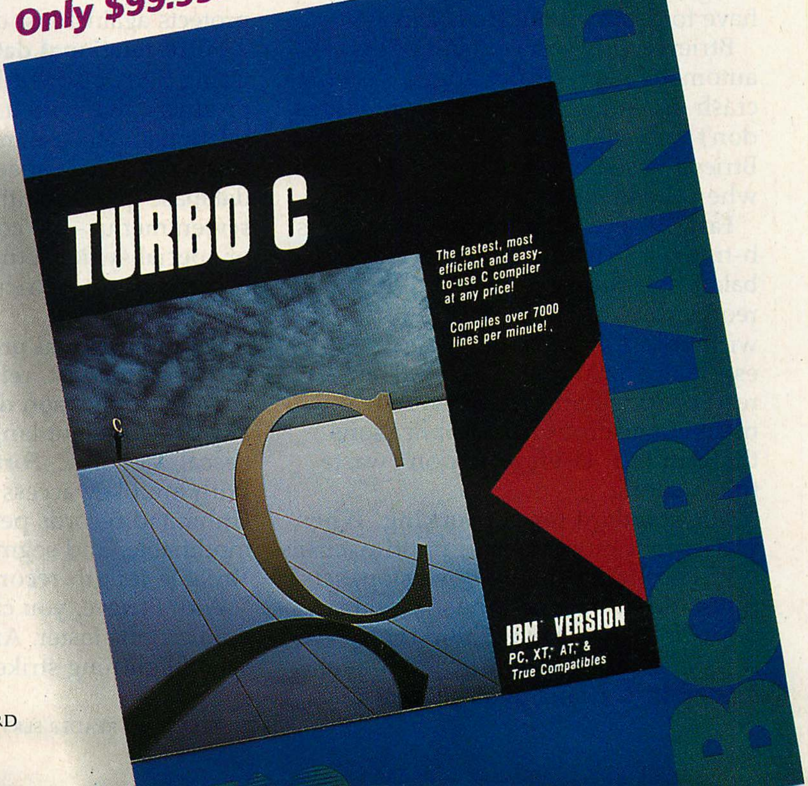

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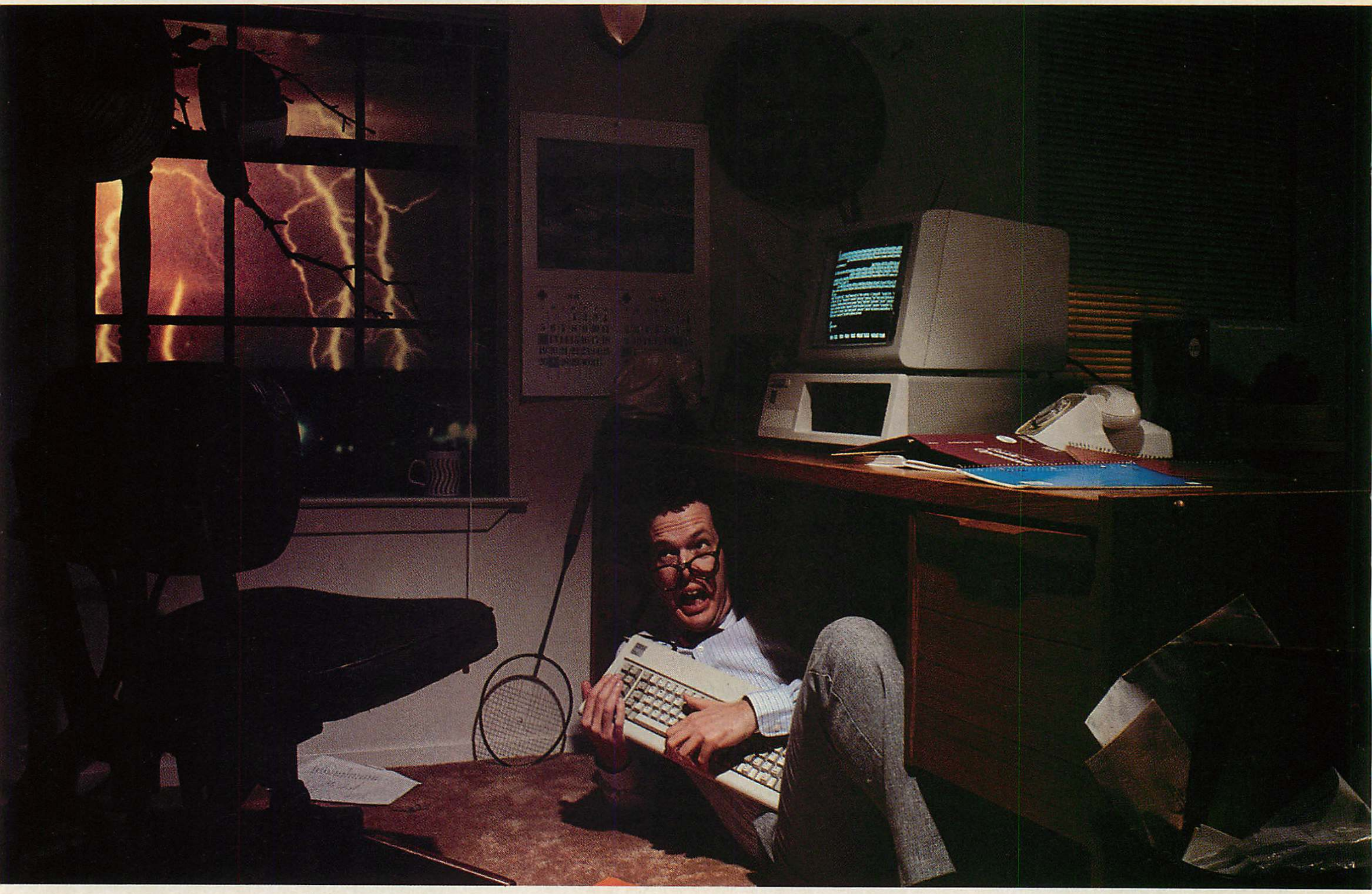

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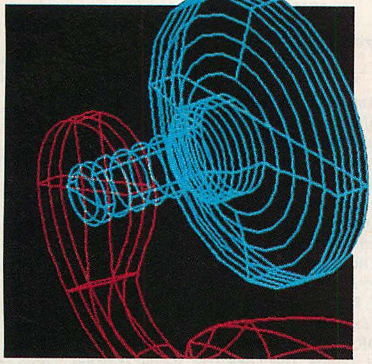

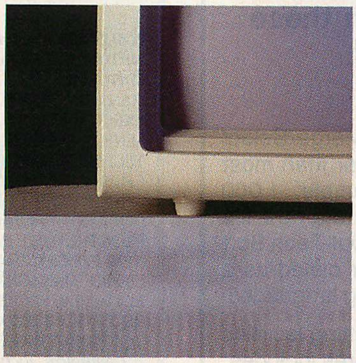

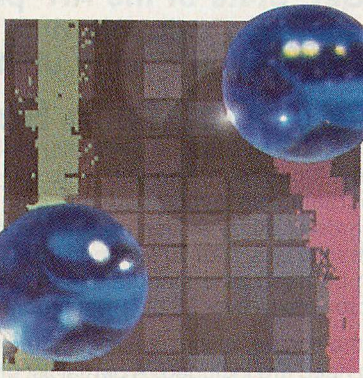

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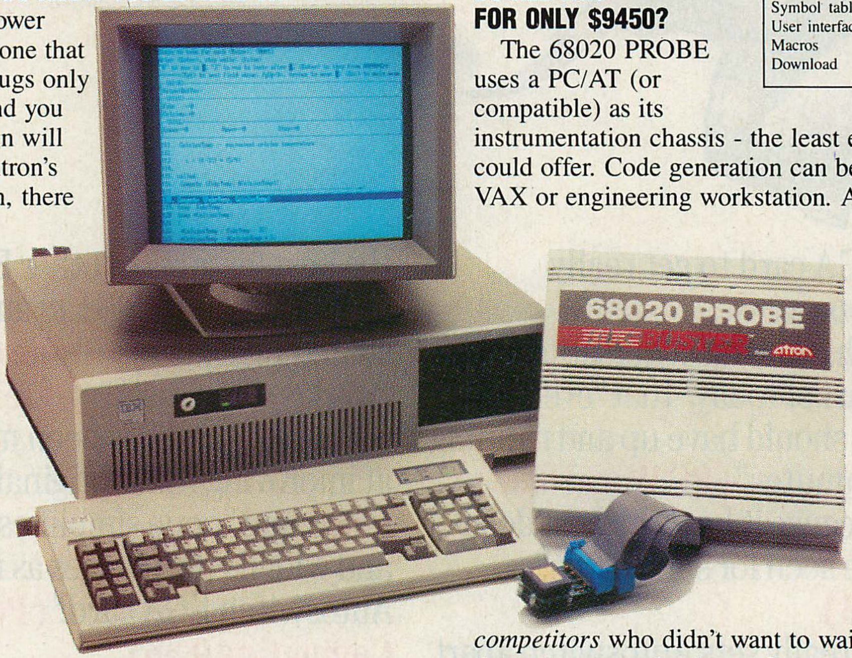

PROBE CAN TRACE IT THROUGH THE PIPELINE, SO YOU WON'T LOSE YOUR MIND.

The 68020 has an on-board pre-fetch pipeline. Without Atron's 68020 PROBE, your best software engineer will spend a lot of time figuring out which instructions actually execute, and then, which bus cycles go with those instructions. The 68020 PROBE eliminates all these tedious mental translations and displays what the processor really did. The technology, called pipeline dequeueing, is only available from Atron. Because the Atron bugbusters are the only ones anywhere who've figured out how to do it. And it took us 100,000 lines of code. Consider it our contribution to your sanity. (It was a dirty job, but somebody had to do it.)

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Just so you'll know we've covered all the bases, the 68020 PROBE supports source-level debugging in C, Pascal and assembler. And when the job of bugbusting is done, you can use the 68020 PROBE as a timing analyzer, with Atron's software version or the *SoftAnalyst* from Northwest Instruments. So you can engineer both reliability and performance. So you can send only the best system into the field.

68020 PROBE SPECIFICATIONS

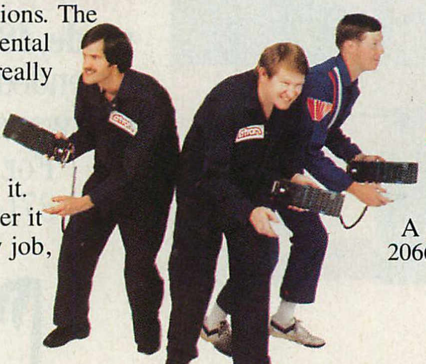
Clock speed	20 mhz
Execution	Transparent
Trace	2048 cycles by 96 bits
	Qualified trace region
	Dequeued trace data
	Pre and center triggered
	Includes symbols and source
	Dynamic cache control
Breakpoints	8 hardware on execute
	Read, write, fetch, logic
	Single or range addresses
	16 software breakpoints
	Sequential triggers - 4 terms
	Real-time pass counter
	Guarded access on memory
	Output lines for cross trigger
	Input lines for external logic
Mapped RAM	512K or 1 megabyte
Source debug	Yes for C, Pascal, Assembler
Symbolic debug	S, Tek, Coff formats
Symbol table	Limited only by AT disk size
User interface	Multiple windows and menus
Macros	Yes, and conditional execution
Download	To target system at 375k baud

HOW CAN ATRON DO ALL THIS FOR ONLY $9450?

The 68020 PROBE uses a PC/AT (or compatible) as its instrumentation chassis - the least expensive solution we could offer. Code generation can be done on the AT, a VAX or engineering workstation. And you don't have to tie up the latter two just for debugging. Smart, eh?

TO WAIT, OR TO WAIT STATE? THAT IS THE QUESTION.

Your choice, now, is a simple one. You can call Atron today. Or you can wait and call Atron tomorrow. And risk losing a production slot to one of *your competitors* who didn't want to wait, or who didn't want the wait-state technology of *our competitors.* So don't wait at all. Call 408/741-5900 today.



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Is UNIX Important?

Recent moves by IBM, Microsoft, Interactive, and AT&T provide food for thought.

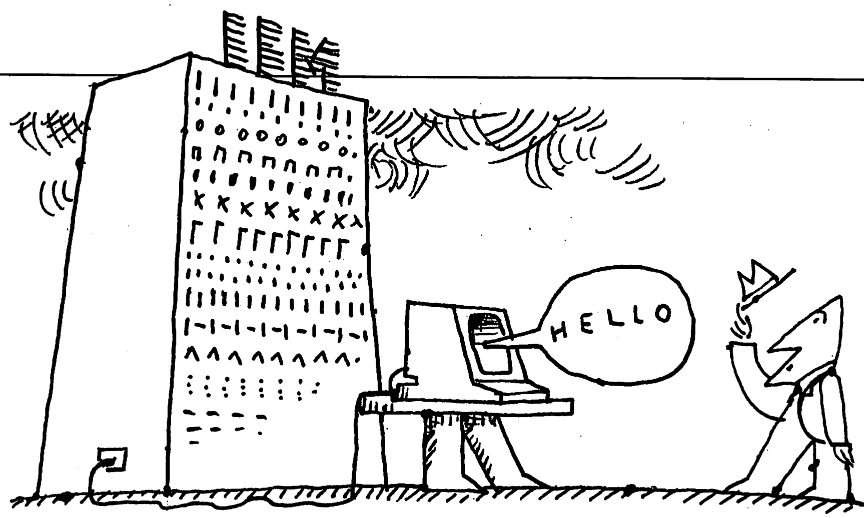


ILLUSTRATION • MACIEK ALBRECHT

Something very important happened to UNIX recently. An improbable group of companies seems to have come to an agreement about it.

Fact 1: Microsoft and Interactive Systems have signed a mutual pact.

Fact 2: Interactive Systems is responsible in large part for several of the UNIX implementations supplied by IBM, including AIX for the RT PC.

Fact 3: Vittorio Cassoni, the head of AT&T Data Systems Group, speaking at the 1987 Personal Computer Forum in February, said that the 80386 would have one binary standard, and he also took some credit on behalf of AT&T for the Microsoft/Interactive deal.

Fact 4: At the recent announcement of enhancements to the RT PC, an IBM spokesman said that AIX would form the basis for UNIX offerings on its entire computer line.

Given the history of UNIX, this is an incredible set of facts and represents a significant, positive step forward. Although IBM and Interactive have worked together for years, AT&T has been touting its own hardware solutions for UNIX and not paying too much attention to the rest of the market (outside of collecting license fees), and Microsoft has been pushing its own XENIX and talking about bridges from MS-DOS. Now these four companies seem poised to nail UNIX's shoes to the floor, to hold it in place long enough to let things stick to it.

This is at once commendable and confusing. It is commendable that four important UNIX companies can be working, if not in perfect harmony, at least toward the common goal of a more secure standard for UNIX; that Microsoft, without abandoning its own identity, is working toward compatibility with IBM's UNIX versions; that IBM is focusing on AIX, perhaps the most commercially viable UNIX port to date; and that AT&T is recognizing the significance of other hardware.

But why this sudden cooperation? What makes working toward a common, standard UNIX a more important goal now than it was, say, a year ago? Have the issues changed? If so, what is the driving force?

A NEW WORLD

AT&T's Cassoni gave us the answer. The driving force is the 80386.

UNIX never achieved much of a foothold in the PC market. Most PCs are not up to the demands of such a large operating system—one that needs both high processor performance and above average disk performance. AT-class machines do not measure up, either. Although the 80286 does have built-in hardware memory management, it lacks other architectural features beneficial to a complex operating environment. Even its memory management is less than a contemporary operating system implementer would prefer. As a result, UNIX imposes considerable overhead when used on both the first and second generations of 86-family processors.

The 80386 changes all that. It is the first processor with all the architectural features required to run a "real" operating system. Most significant is the demand-paged, virtual memory management system that is, like its counterpart on the 80286, built into the processor. It has the performance, especially when coupled with high-speed mass storage. Better yet, it is a de facto part of the IBM PC standard, which means that a host of companies is working on 386-based, AT-compatible systems.

That is a most important fact. The number of UNIX installations, rumored to have doubled last year, has not yet reached a commercial critical mass. The current market is being fed by a plethora of companies with proprietary hardware architectures (everyone from Sun to Data General and dozens of others). Portability is not as good as the UNIX community would have us believe, however, because a significant share of the UNIX market falls in the workstation category, where exploiting the underlying hardware is often important. What an AT-compatible 386 machine (or even a new IBM standard machine) promises to do is reduce the number of variables that an application vendor needs to worry about. That is the essence of MS-DOS on the current IBM standard.

A computer's memory management unit is a key to stabilizing the hardware. This was the argument for XENIX 286 put forth by Microsoft's Bill Gates, and it applies equally to the 386. The point: *every* 386 system installed has precisely the same, built-in memory unit. A manufacturer can provide a more advanced,

external subsystem, but the memory architecture of the 386 is more than satisfactory; a vendor with such a strategy would be taking a major risk.

In short, the 80386 represents a stable, standard, hardware platform, and there are going to be a lot of 386 machines within the next two years.

WHO CARES?

For starters, IBM, AT&T, Microsoft, and Interactive Systems care. Second, all the manufacturers of UNIX-based software who would like to see improvement in their growth curve and jumps in their profitability care. Oh, I almost forgot: Apple cares.

Apple may be the catalyst that has companies on the other side of the architectural fence running so scared that they would resort to a very close working arrangement. Why? Because right now the workstation market is focused on machines using the 68000 processor family. Apple, by the time you read this, will have announced the Open Mac. I suspect that UNIX will have been announced for the machine; if not, expect it shortly if for no other reason than Apple President and CEO John Sculley's statement at the PC Forum that Apple is committed to UNIX.

The details of Open Mac are fuzzy, but clearly it will be an excellent platform for workstation products. Perhaps more important, the Mac interface has more in common with the dedicated workstation products than does the IBM PC interface, so buyers in that market will naturally gravitate toward such a machine. Sculley is not exactly immodest about Apple's future, but he may be too modest about prospects in the workstation segment.

That leaves those of us on this side of the fence with a big problem. I am sure that IBM and AT&T would like a piece of the workstation pie. Microsoft and Interactive undoubtedly would like a more significant revenue stream from 86-family UNIX software products. Certainly the application vendors want their potential market (that is, the total number of UNIX-capable machines installed) to grow, grow, grow.

This is the reason for the sudden and serious cooperation. The right hardware is here today and more is just around the corner. If the vendors committed to the 86 architecture do not act quickly, every workstation in sight will probably sport that little Apple logo.

DO WE CARE?

It is probably safe to say that the majority of *PC Tech Journal* readers are not involved in the workstation market. Then, why am I making such a fuss?

We may not be looking for workstations, but we do need 386-class machines applied to other tasks. One particularly important area is the network server. Eventually, it would be nice if servers ran the same operating system found on the network's nodes, meaning MS-DOS. The rumor mill to the contrary, it will be some time before we see a version of DOS for the 386. (In fact, it may be some time before we see one for the 286.) In the meantime, LAN is headed for critical mass.

In order for LANs to be effective in a general-purpose environment, servers need to become smarter. They need to be able to execute code in support of the network applications (and not just electronic mail). Data servers will need data manager stubs to process queries. Printer servers will need page description language translators and drivers (if they are not built into the printer). Transaction systems will need local intelligence in gateways.

When a vendor delivers a network server with proprietary operating software, adding intelligence to the server is not possible because the vendors of products such as data managers are not going to build their network stubs for all the different operating systems. Because this need is beginning to become apparent, UNIX-based servers represent a strong alternative to what is bound to be the long-awaited 386 DOS.

A 386 machine, even in the AT class, is a very good platform for dedicated applications, the type that are traditionally supported by timesharing, multiuser systems with dumb terminals. Enormous opportunity exists for systems of this type, especially in small businesses where the cost per node of a LAN solution is prohibitive and the flexibility delivered by networked PCs is simply not required.

The foothold that UNIX can gain in the PC marketplace remains uncertain. Increased competition, the availability of a suitable hardware platform, and just plain pride on the part of the participating companies may drive UNIX toward its own critical mass in a market that has traditionally shunned it.

INSPIRING CONFIDENCE

One problem in the computer industry is that so many companies fail to understand just how long their development efforts will take. Provoked by fierce competition for the dollars of customers and the attentions of journalists, companies tend to announce a product too soon and then are not able to meet their own deadlines.

Such behavior hardly builds confidence. At least two companies, however, have impressed me with how well they have kept to their plans (even if their schedule slipped a bit) and maintained their focus.

The first is Gold Hill Computing, manufacturer of Golden Common LISP, a developer's toolkit, and the soon-to-be-released GoldWorks (formerly Acorn), an expert-system tool. A year ago Gold Hill CEO Carl Wolfe candidly laid out his long-range plan; he was so frank that I almost dismissed what he was saying as braggadocio. Late last year Wolfe outlined the same plan, with milestones reached and others clearly in sight.

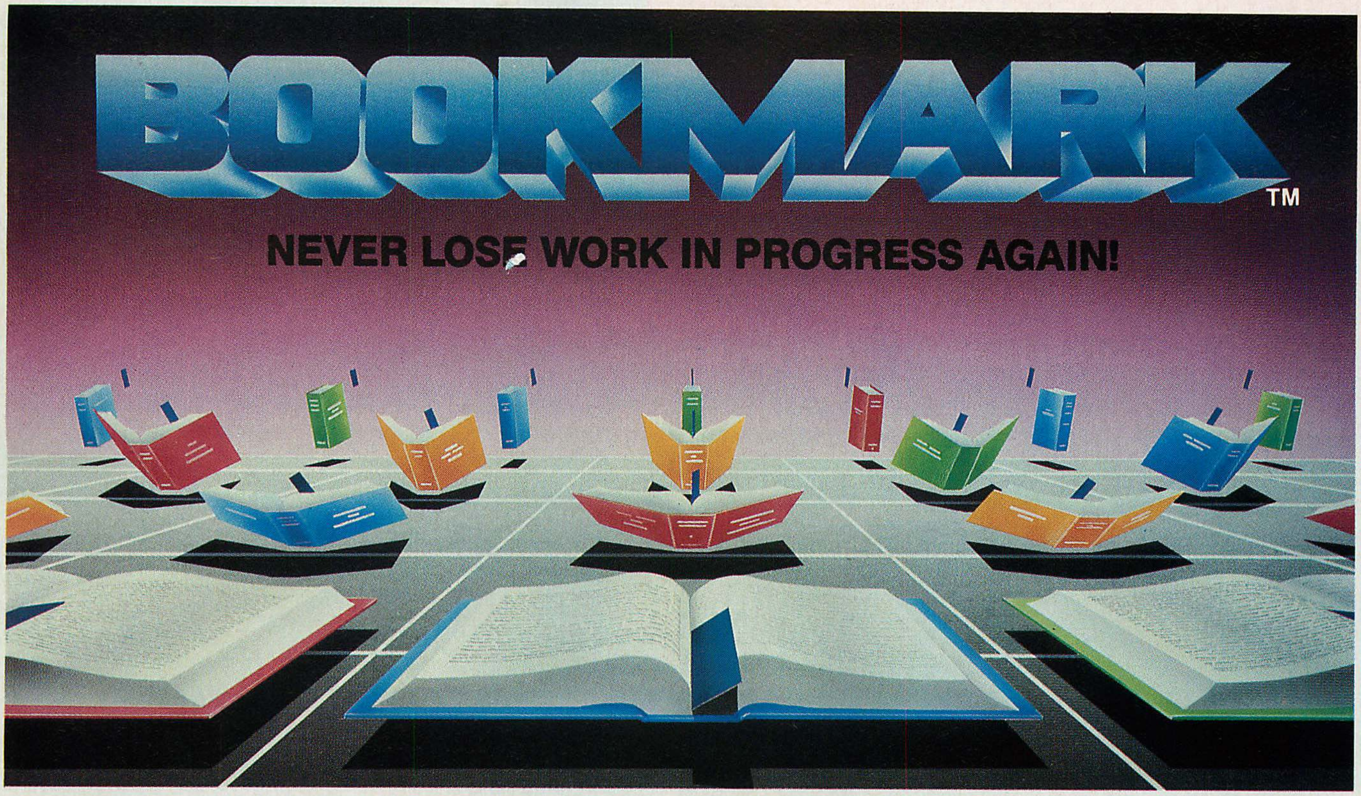
This is especially impressive because the Gold Hill products are complex, requiring the efforts of not only LISP programmers but also those knowledgeable in expert systems and artificial intelligence. The higher complexity of the software increases the likelihood of scheduling errors. Gold Hill seems to have avoided the pitfalls, and the important side effect is that people will listen to Wolfe's posturing about the future much more carefully.

The second company to impress me with its planning is Compaq. Although *PC Tech Journal* was not privy to a year's-eye view, we were given a few advance hints, which, combined with a growing respect for Compaq's serious and thoughtful managers, convinces us that, indeed, the firm is planning very carefully.

Compaq also is able to focus, an ability sorely lacking in so many companies. Its portable model has been successively refined with smaller, lighter, faster, and better machines. Even though Compaq now makes desktop models, it promotes its own mystique by producing better versions of the machine that fueled its extraordinary business success.

Gold Hill and Compaq merit special recognition for delivering the goods. They also should stand as models for other firms that, perhaps, are struggling too much.

—*WF*



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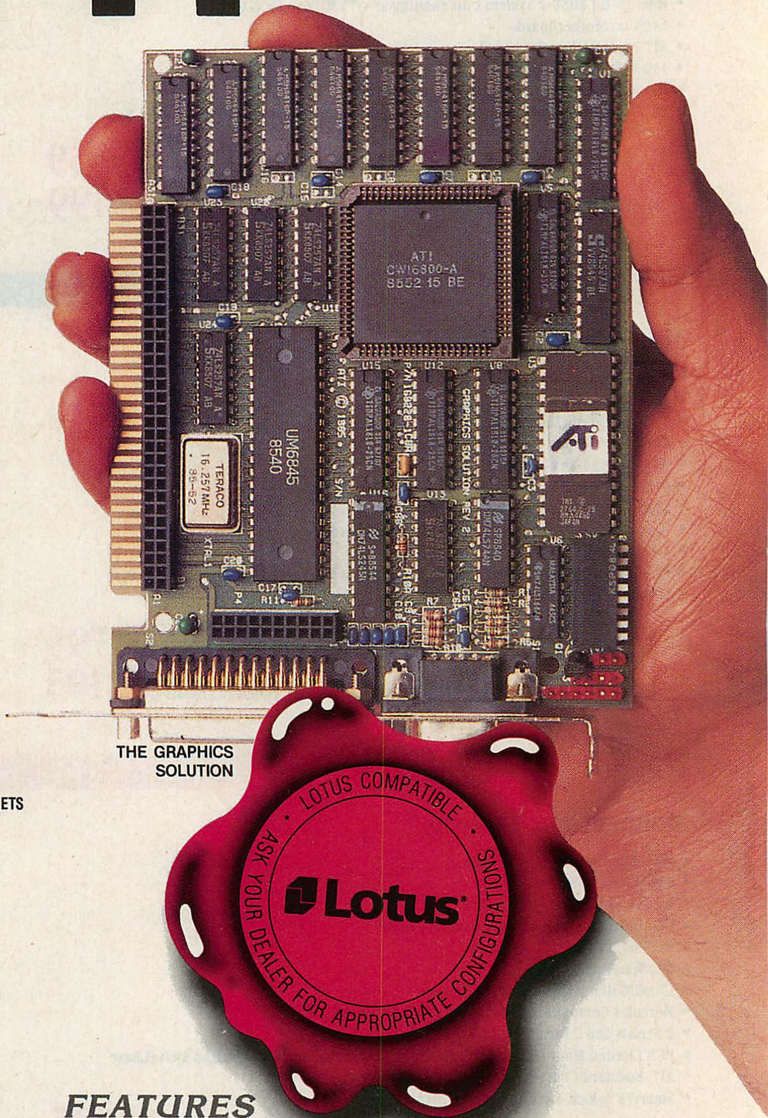

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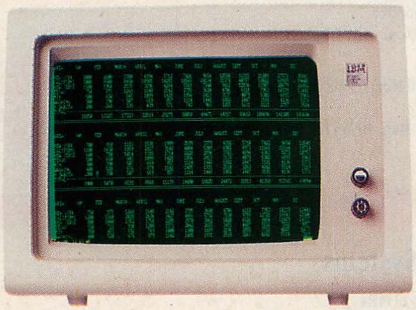

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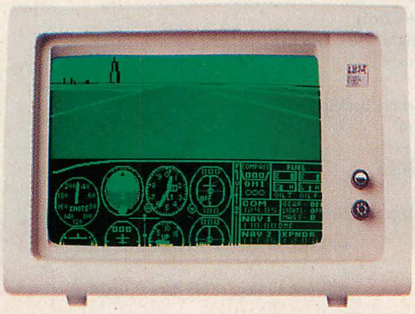

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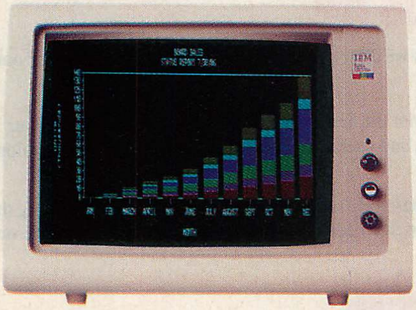

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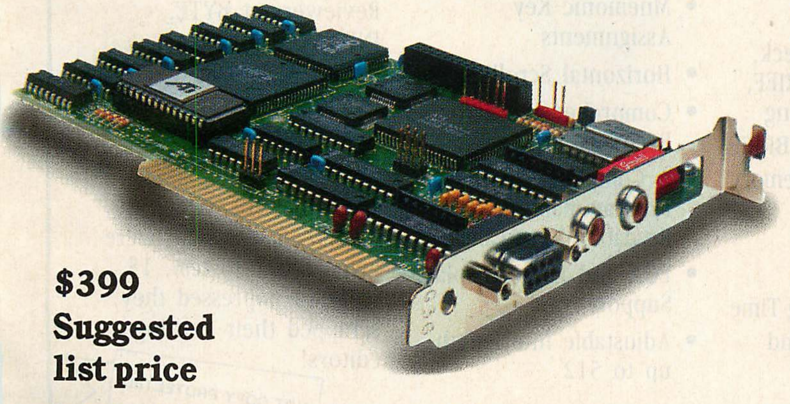

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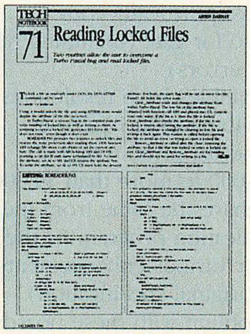

MOUSETRAP

I agree wholeheartedly with Jeff Duntemann's favorable review of the Logitech Logimouse C7 (Product Watch, December 1986, p. 185). I recently bought one for use on my own personal PC/XT-compatible system, and I much prefer it to the Microsoft Mouse that I use at work. The fact that the Logimouse is such a good value is icing on the cake.

However, I have one caveat for prospective buyers: I ordered my Logimouse from a distributor (Programmer's Connection) and was pleased to receive it in less than a week. Upon opening the package, though, I was puzzled to find a very different mouse than the one I expected. Instead of three large flat buttons, I found three sets of "ribs" poking through slots where the buttons should have been. For my money, the feel of these ersatz buttons wasn't anywhere near as good as those of the conventional Logimouse that I had tried earlier.

When I called about this, the distributor's salesperson seemed completely unaware of any question regarding the Logimouse buttons. She thought all mice that are available from Logitech had the same buttons (the "fancy" kind) and suggested that I call Logitech's customer service number.

The Logitech customer service representative knew all about the new buttons—she referred to the two different button styles as the "conventional" button and the "fluted" button. It seems both styles are current, and both are being shipped more or less at random. Mine was evidently not the first complaint, because even before I asked, she said that I could return my fluted-button mouse for replacement with a conventional-button mouse. I did.

In sum, I would advise users to specify the button style when ordering a Logitech Logimouse. The salesperson may not be aware of the distinction between the two styles, and I have never seen this difference mentioned in the company's advertisements or even in the user's manual.

Richard M. Kruse
Prairie Physics
Wichita, KS

Mr. Kruse is not alone. When PC Tech Journal *first received a Logimouse C7 for review, it too had the fluted-button design. Worse, when the center button was pressed, a slight misalignment of the case caused it to stay down, and the screws holding the case together had to be loosened to get the button to release. According to Logitech, the fluted design is popular in Europe, but it was never intended for the U.S. retail channel. A few have appeared in U.S. distribution, however, and Logitech has promised to replace any fluted-style mouse with a conventional mouse at no charge. The packaging is identical, so the distributor has no way of knowing which mouse is on the shelf without breaking the shrink wrap and looking inside.*

—Jeff Duntemann

ALL BOTTLED UP

Once again I find myself amused by complaints about graphics processors ("Display Adapter Bottleneck," Michael Abrash, January 1987, p. 104). Mr. Abrash starts off with a noble mission since many programmers do not seem to understand the implications of wait states in accessing display memory. However, I think the article really misses the point by suggesting that awareness of the problem is the best solution. It is time we admit that this "state of the art" graphics board—the IBM Enhanced Graphics Adapter (EGA)—is simply inadequate. The insertion of multiple wait states is just one example of the EGA's weakness. Even more alarming is the complex interface that makes the EGA the most nonportable graphics device around and does little to enhance performance.

If the user really wants to make a fast display buffer, it would be very easy to beat the EGA. Here are three rather obvious techniques: First, tighten up the memory cycle timing to make good use of the memory bandwidth instead of minimizing the complexity of the control logic. Given the overall complexity of the EGA chip set, the additional logic required to do this is insignificant.

Second, buffer display RAM write operations. By this I mean to latch the address and data to be written, letting the CPU go on to the next instruction without any wait states. The sequencer then would perform the write cycle in the next available slot. Wait states would be inserted only when the CPU tried to perform another access to the display RAM (or GDC control registers) before the first operation was completed.

Third, use video RAMs (dual-ported RAM devices designed specifically for display buffers). This can reduce display refresh cycles to less than 5 percent and vastly simplify the complexity of the control circuitry. To be fair, video RAMs were not available at a reasonable price at the time the EGA was designed. Until quite recently they were available from only one manufacturer (in the 256KB density) and so the price was artificially high. But today there is very little reason not to use them.

So what are end users to do? Build their own graphics boards? Suffer CGA (IBM Color Graphics Adapter) graphics until something better comes out? I think anyone interested in high quality, speedy graphics should look at the various (IBM Professional Graphics Controller) PGC-compatible products on the market. Unlike most graphics boards around, these boards present a simple, generic interface and a native graphics command set that eliminates a large part of the effort involved in writing a graphics application. PGC-compatible boards have been implemented with a variety of architectures and characteris-

tics. EGA clone manufacturers, on the other hand, must practically copy the IBM design, gate for gate (including numerous design errors).

PGC compatibles have resolutions ranging from 640-by-480 to 1,280-by-1,024 pixels, and list prices ranging from under $1,000 to more than $4,000. Yet, they all behave the same from the view of an application program or the user (except for various enhancements beyond IBM's original specification). The biggest problem with these boards is that some software developers seem to resent that a hardware product now performs tasks that used to be their job. Some popular graphics toolkit products on the market today are rendered totally obsolete by the PGC. And with the excitement over new graphics controllers, such as Texas Instruments' 34010, everyone seems to be saying that is the way it should be.

Greg Marshall
Fremont, CA

I certainly agree that the EGA is a low-performance display adapter with a quirky architecture (although this relates only tangentially to the topic of the article). I do not agree that the EGA is inadequate, however, and I am not sure it makes a difference to state that claim in any case. At least half a million EGAs are now installed, and they continue to sell briskly; developers have no choice but to support the EGA, warts and all. Inadequacy is judged by the marketplace; in that sense, the PCjr was inadequate, but the EGA is not. Railing against the deficiencies of the EGA is somewhat like complaining about the inferiority of the 8088 relative to the 68000: it may or may not be true, but given that the largest installed base of computers in history is built around the 8088, it is not particularly relevant.

Mr. Marshall suggests three ways in which EGA performance might be improved. Frankly, given the architecture of the EGA, I doubt that the display adapter bottleneck can be significantly eased, and a review of Mr. Marshall's suggestions reinforces this point.

The first suggestion is tighter memory timing. This has been implemented already by several chip manufacturers, including Chips and Technologies and Tseng Labs, and does indeed improve the performance of bit-mapped interfaces perceptibly. However, the EGA is still an 8-bit device (and because of pin counts will likely remain so); therefore EGA performance in the PC/AT is improved by a ratio of only about 2:1, at best. Performance on 80386-based computers is similarly limited.

The second suggestion is the buffering of display RAM writes. This would be of little help in the case of multiple successive accesses, which is where the bottleneck matters most. This case includes block copies to EGA memory and block copies with EGA memory as both source and destination, which are used heavily in window-oriented and animated EGA programs. In particular, virtually no speed improvement would result in the case of block copies involving EGA memory on ATs and 80386-based computers, because these computers request successive accesses much faster than the EGA perform them.

The third suggestion is the use of video RAM. Given the EGA's design, it would be difficult to use video RAM, most notably because the fonts, which are stored in video memory, must be accessed randomly, and because of the virtual screen width capability.

In short, a fully compatible, higher-performance version of the IBM EGA is unlikely to appear. Moreover, the price/performance ratio of the EGA seems to be more than acceptable to the PC market right now; thus, the EGA will likely remain the standard for some time.

—Michael Abrash

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CODE READ

In Tech Notebook 71 ("Reading Locked Files," December 1986, p. 51), Arsen Darnay provides a complicated and potentially dangerous method of handling read-only files with Turbo Pascal. Unlocking a read-only file creates the possibility of accidentally erasing the file if the program fails or is interrupted before it relocks the file. Suppose the program ROREADER, using this method with the read-only file SAMPLE.TXT, is invoked from the file:

```
ROREADER.COM
REM        Next erase all .TXT files
ERASE *.TXT
```

If ROREADER fails before relocking SAMPLE.TXT, the file would be erased.

Additionally, the global variable F_Attr *must* be safely maintained in order for the Restore_Attr procedure to correctly restore the original file attributes. A simple programming error might alter the value of F_Attr, thus causing Restore_Attr to change the file attributes to something different.

To top it off, many applications running in a network environment *require* that a file be set to read-only in

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order that multiple users may access it simultaneously. As soon as the procedure Clear_Attr cleared the file's read-only attribute other users on the network might not be able to access it.

Because Turbo Pascal (version 3.x) uses the DOS function call 3DH to open a file, a much safer way to open read-only files is to temporarily change the mode byte that Turbo Pascal passes to DOS to a zero (for read-only access). In the regular version of Turbo Pascal, this byte is located in the code segment at offset 24FCH. In the 8087 version, it is at offset 1FABH, and in the binary-coded-decimal (BCD) version, it is at 2402H. A sample program demonstrating this method is as follows:

```
Program Open_RO;

Var
  InFile     : Text;
  Tmp_Mode   : Byte;
  Mode_Byte  : Byte Absolute CSeg:$24FC;

  { Note: use CSeg:$1FAB for 8087 version,
              CSeg:$2402 for BCD version  }

Begin
  Tmp_Mode   := Mode_Byte    { save mode }
  Mode_Byte  := 0;           { read only }
  Assign(InFile,  'Sample.Txt');
  Reset(InFile);
  Mode_Byte := Tmp_Mode;     { restore mode }

  { now read and use the file normally }

  Close(InFile);
End.
```

This far safer method also works when reading normal files.

Ernest G. Allen
Tri-Cities, WA

I was delighted to see this elegant solution offered by Mr. Allen. The Tech Notebook reported my solution to a particular problem that I had devised on short notice, without benefit of disassembling the Turbo Pascal code.

My approach arose in an environment where files are locked daily and kept locked. The files are edited using WordStar—which has no difficulty reading locked files. Upon saving the file, it renames the old file by replacing (or adding) the .BAK suffix and then creating a new and unlocked file under the old name. DOS 3.1 permits renaming a locked file. A number of Turbo Pascal utilities are used on these files as well; they both read and write data. Hence, there is a need to lock and unlock the files. Nevertheless, Mr. Allen's cautions are well worth heeding.

—Arsen Darnay

The method recommended by Mr. Allen works as he has described, and with far less programming effort than Mr. Darnay's solution. However, because code patches can cause unexpected side effects and the correct patch location can vary depending upon the version of software, any type of modification to Turbo Pascal's library can be risky. If a patch is used, new versions of Turbo Pascal must be checked to make sure the patch is still valid. Building a self-check into the code (before the patch is made) is a good idea. For example, Mode_Byte is actually part of the instruction MOV AX,3D02H where 3DH is the DOS open-file function and 02H is the original value of the mode byte. The program can make sure it is modifying the correct location with the code that immediately follows.

—DM

```
Var  Patch_check : Word Absolute CSeg:$24FB;

If Patch_check <> $3D02 then
   writeln('Wrong version of Turbo Pascal!');
```

BASIC CONSIDERATION

With regard to "Reconsidering BASIC" (Marty Franz, December 1986, p. 142), I do not see how *any* BASIC compiler can be considered even satisfactory if it does not support the 8087/80287. For some of us, the whole purpose of computers is to compute. The numeric coprocessor not only speeds calculations, it performs them with more accuracy. Professional BASIC from Morgan Software is precompiled, has excellent trouble-shooting aids, and has always supported the numeric coprocessor.

Russ Roberts
La Habra, CA

It is true that users who perform a large volume of floating-point computations generally require 8087 support. The compiler review that Mr. Roberts mentions notes that both Pecan BASIC and Softaid MTBASIC offer support for the 8087. Professional BASIC was reviewed as an interpreter in "Six New Shapes of BASIC" (Ted Mirecki, June 1986, p. 52); it supports the 8087, as do some other interpreters reviewed—BetterBASIC from Summit Software, True BASIC from True Basic, Inc., and WATCOM BASIC from Waterloo Computing.

—JS

I just purchased Microsoft's QuickBASIC 2.0 after reading your review of BASIC compilers. I am confused by one thing. Table 1 of the article (on page 144) in-

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dicates that QuickBASIC supports BCD math. After searching the manual, I called Microsoft, only to be told that QuickBASIC does not support BCD math. Could you please publish a correction so that others are not misled.

Dwight Carter
Augusta, KS

Microsoft verifies that QuickBASIC does not support BCD math. PC Tech Journal *regrets the error.*

—CE

UP THE WRONG TREE

I am writing to correct several inaccuracies in Marshall Brain's Programming Practices column in the December 1986 issue ("Jump Searching Linked Lists," p. 177). It appears that Mr. Brain does not know the difference between binary trees and B-trees. These data structures are both *trees*, but that is where any similarity ends between the two.

The B-tree concept is a relatively new one, attributed to R. Bayer and E. McCreight in 1970. A B-tree is a dynamically self-balancing tree. It is constructed from the bottom upward. This type of tree cannot become unbalanced by any sequence of additions or deletions, and it never needs to be rebuilt or rebalanced for any reason. Depending on the order of the B-tree, each record may have any number of sons. Using a B-tree of order 21 (a reasonable order), any record that is within a file containing 4,084,100 records is accessible with a maximum of five disk accesses. Jump searching simply cannot achieve this level of performance.

A binary tree is defined recursively as either being empty or as a node with either zero, one, or two binary trees attached. Each node can branch in no more than two ways. It is constructed from the top downward. It can become unbalanced if the keys of records being added are not in random order, but rather in ascending or descending sequence. However, regarding deletions, Knuth volume 3 (*The Art of Computer Programming*, D. E. Knuth, Addison-Wesley, 1973) states that if a random element is deleted from a random binary tree, the resulting tree is still random. Finally, concerning rebuild times, Knuth contains a very good algorithm that rebuilds an N-record tree in an order of *N* steps.

Michael E. Wengler
Computer Related Services, Inc.
Virginia Beach, VA

I thank Mr. Wengler for taking the time to comment on my article. I would like to respond to two of his points.

First of all, jump searching is a simple technique that can be added quickly on top of an existing linked-list structure without the need for fundamental code modification. It provides search times that are significantly faster than linear search times. As stated in the article, jump searching is not a replacement for a tree of any kind, because trees are inherently faster. A specific example in the article demonstrates that jump searching is approximately 50 times faster than a linear search of 10,000 elements, but it is about 7 times slower than a binary tree search. Because jump searching is much easier to implement than is a binary or B-tree structure, it is, as I suggested, a technique "worthy of consideration."

Second, Mr. Wengler is correct to point out that binary trees and B-trees are different structures. The article was written to compare jump searching to binary trees only, not B-trees. In the process of being published, "binary

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trees" was mistakenly abbreviated in the article to B-trees. B-trees have some problems of their own, such as added complexity and space consumption.

—Marshall Brain

STANDARD ISSUE

Will Fastie may have identified a legitimate problem in "The Printer Standards Gulf" (Directions, January 1987, p. 9), but he omits any mention of the standards that already exist in this area. The problem is due to the failure to observe existing standards as well as the failure to establish new ones. By "standard" I mean a document that is adopted as such by the American National Standards Institute (ANSI).

In the original standard code for information interchange (ASCII, X3.4-1967, revised 1977), provision for code extension was made by its inclusion of two shift characters. The first one, SO, is intended to select an alternate code subset; the second, SI, is intended to restore the base subset.

The code extension standard (X3.41-1974) defines mechanisms by which multiple extended code subsets may be invoked. These are known as G1 sets if they are alternate graphic (that is, not control) character sets, such as italics on Epson printers and the line-drawing graphics on IBM printers. X3.41 allows 126 G1 sets.

While it would be better if one of the principal printer definitions could be chosen as the base for a standard, both the Epson and IBM implementations conflict with the existing standards, such as in the use of SO and SI, which are fundamental to the standard code extension mechanism. A standard extended printer code can accommodate all of the graphic symbols in common use today, but it cannot do so in a manner that is upwardly compatible with any existing printer.

The situation is identical to that experienced by video display users a few years ago. While a few implementations dominated, innumerable variants were available. None of these was sufficiently general to form a base for a standard, hence a new implementation was defined along the lines prescribed by X3.41. This was adopted as X3.64. Conforming terminals are now known as ANSI-compatible terminals. Nonconforming terminals are still supported on many systems by enumeration or by virtual terminal definitions.

Printer standardization will likely follow a similar course. Any serious proposal for a standard must first take the existing standards into account and then build on them. I would recommend to any persons who wish to contribute to the solution of this problem that they first read the standards cited in their original form.

Gary A. Hill
St. Paul, MN

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The HAMMER *by OES Systems*	195	129
MetaWINDOWS *No Royalties*	185	109
MetaFONTS	80	58
MetaWINDOWS/Plus *by Metagraphics*	235	185
MetaFONTS/Plus	235	185
PANEL *by Roundhill Computer Systems*	295	215
PC Lint *by Gimpel Software*	139	99
PLOTHI *by Sutrasoft*	175	159
PLOTHP *by Sutrasoft*	175	159
Professional C Windows *by Washburn* New	CALL	CALL
Scientific Subroutine Library *by Peerless*	175	128
screenplay *for C by Flexus*	175	129
Vitamin C *by Creative Programming*	225	158
VC *Screen Forms Designer*	100	79
Zview *by Data Management Consultants*	245	169

cobol language

EASY SCREEN *by Retail Mgmt Systems* New	225	199
Micro Focus COBOL Workbench	4000	CALL
Micro Focus Level II COBOL	1500	CALL
COGRAPHICS	250	CALL
COMATH	200	CALL
FORMS-2	300	CALL
Level II Animator	900	CALL
Level II SOURCEWRITER	2000	CALL
Micro Focus Level II COBOL *for Novell*	2000	CALL
Micro Focus Professional COBOL	3000	CALL
Multi-user Runtime *for PC Network*	500	CALL
Microsoft COBOL *See Microsoft Section*		
Realia COBOL	995	783
REALCICS New	995	783
REALMENU New	150	119
RM/COBOL *by Ryan-McFarland*	950	CALL
RM/COBOL 85 *by Ryan-McFarland*	1250	CALL
screenplay *for COBOL by Flexus*	175	129

debuggers & profilers

386 DEBUG *Cross Debugger by Phar Lap*	195	129
Advanced Trace-86 *by Morgan Computing*	175	115
CI Probe *by Computer Innovations*	225	CALL
Codesifter *Profiler by David Smith*	119	85
Codesmith-86 *by Visual Age*	145	98
DSD86 *by Soft Advances*	70	61
DSD87 *by Soft Advances*	100	79
MiniProbe *by Atron*	395	CALL
Periscope I *with Board by Periscope*	345	289
Periscope II *with NMI Breakout Switch*	175	139
Periscope II-X *Software only*	145	105
The PROFILER *with Source Code by DWB*	125	89
The WATCHER *Profiler by Stony Brook*	60	51

dos utilities

Command Plus *by ESP Software* New	80	69
FANSI-CONSOLE *by Hersey Micro*	75	62
MKS Toolkit *with vi Editor by MKS*	139	99
Norton Commander *by Peter Norton*	75	55
Scroll & Recall *by Opt-Tech Data*	69	59
Taskview *by Sunny Hill Software*	80	56

entelekon products

C Dynamo New	250	209
C Dyanamo Screen Painter New	130	109
C Function Library	130	109
Dyanamo Data Entry New	130	109
Power Windows	130	109
Superfonts for C	50	43
Screen Painter & Data Entry New	180	150

essential products

C Essentials *by Essential Software*	100	75
C Utility Library	185	119
Essential Comm Library *with Debugger*	250	189
Essential Comm Library *Software Only*	185	125
Breakout Debugger *Any language*	125	89
Essential Graphics	250	183

forth language

CFORTH *Native Code Compiler by LMI*	300	229
Forth/83 Metacompiler *Specify Target*	750	599
PC/Forth *by Laboratory Microsystems*	150	109
PC/Forth+ *by Laboratory Microsystems*	250	199
Advanced Color Graphics Support	100	74
Enhanced Graphics Support	200	148
Intel 8087 Support	100	74
Interactive Symbolic Debugger	100	74
Native Code Optimizer	200	148
Software Floating Point	100	74
UR/Forth *by LMI*	350	279
Object Module Libraries	500	395
Source Code License	1500	995

fortran language

50 MORE: FORTRAN *by Peerless Engr*	125	95
ACS Time Series *Alpha Computer Service*	495	389
Essential Graphics *by Essential Software*	250	183
For-Winds *Alpha Computer Service*	90	69
Forlib-Plus *Alpha Computer Service*	70	44
FORTLIB *by Sutrasoft*	95	85
FORTRAN Addendum *by Impulse Engr*	95	85
FORTRAN Addenda *by Impulse Engr*	165	138
GRAFLIB *by Sutrasoft*	175	159
HALO *by Media Cybernetics*	300	205
I/O PRO *by MEF Environmental*	149	129
Microcompatibles Combo Package	240	215
Grafmatic	135	117
Plotmatic	135	117
Microsoft FORTRAN *w/CodeView* New Version	450	269
No Limit *by MEF Environmental*	129	115
Numerical Analyst *by MAGUS* New	295	CALL
PANEL *Screen Designer by Roundhill*	295	215
PLOTHI *by Sutrasoft*	175	159
PLOTHP *by Sutrasoft*	175	159
RM/FORTRAN *Ryan-McFarland*	595	CALL
RTC PLUS *Fortran to C by Cobalt Blue* New	325	CALL
Scientific Subroutine Lib *by Peerless*	175	128
Statistician *Alpha Computer Service*	295	245
Statlib.GL: *by PSI/Systems* New	295	239
Statlib.TSF: *by PSI/Systems* New	295	239
Strings & Things *Alpha Computer Service*	70	51

greenleaf products

Greenleaf Comm Library	185	125
Greenleaf Data Windows	225	157
with Source Code	450	289
Greenleaf Functions	185	125

help utilities

HELP/Control *by MDS*	125	99
On-line Help *from Opt-Tech* New Version	149	99
SoftScreen/HELP *by Dialectic Systems*	195	149

lattice products

Lattice C Compiler *from Lattice*	500	269
with Library Source Code	900	495
C Cross Reference Generator	50	37
with Source Code	200	139
C-Food Smorgasbord *Function Library*	150	95
with Source Code	300	179
C-Sprite *Source Level Debugger*	175	129
Curses *Screen Manager*	125	89
with Source Code	250	174
dBC II *Specify dBC II or dBC III*	250	169
with Source Code	500	356
dBC III Plus New	750	CALL
with Source Code New	1500	CALL
LMK *Make Facility*	195	138
RPG II Combo *All three items below*	1100	875
RPG II Compiler *No Royalties*	750	625
RPG II SEU *Screen Entry Utility*	250	199
RPG II Sort/Merge	250	199
RPG II Screen Design Aid Utility	350	309
SecretDisk *File Encryption Utility*	120	89
SideTalk *Resident Communications*	120	89
SSP/PC *Scientific Subroutine Library*	350	269
Text Management Utilities	120	89
TopView Toolbasket *Function Library*	250	178
with Source Code	500	356

microport products

System V/AT *by Microport Systems*	499	429
Runtime System *(Operating System)*	199	189
Software Development System	199	189
Text Preparation System	199	189
User Upgrade *3 to Unlimited Users*	CALL	CALL

ZIM DEFINES THE WORDS

1) Productivity
2) Portability

ZIM®, the definitive 4GL/DBMS for the serious application developer, brings new meaning to words like "productivity," "portability," "power" and "performance." That's because in four short years **ZIM** has established a *new* standard of database design, the Entity-Relationship (E-R) model, and in doing so, has created new standards by which all other 4GLs are measured.

Productivity **ZIM** delivers productivity improvements over the entire development lifecycle, from requirements all the way through maintenance. Although other products demonstrate a 10:1 productivity gain in the coding phase of systems development, **ZIM** outperforms them in all stages, as shown below.

	Productivity Gain
REQUIREMENTS	10:1
CODING	25:1
DOCUMENTATION	5:1
MAINTENANCE	20:1
AVERAGE	15:1

ZIM productivity across the development lifecycle

At the core of **ZIM** users' gains is the E-R model, a graphically-oriented data model that eclipses traditional Relational models because it recognizes relationships *between* tables of data as well as those within. **ZIM**'s pre-defined relationships permit the implementation of many-to-many relationships, outer joins, and relationship consistency with an ease not found in any other product.

Intrinsic to **ZIM**'s E-R orientation is the code-reducing **ZIM** language. Since **ZIM** code is a generation ahead of 3GLs (like COBOL) and much tighter than other 4GLs, your development time is slashed accordingly.

```
SQL:
SELECT *
FROM WORKONTAB, PROJECTS, EMPLOYEES-
WHERE WORKTONTAB.ENUM = EMPLOYEES.ENUM-
AND WORKONTAB.PNUM = PROJECTS.PNUM-
AND PROJNAME = 'ALPHA'

ZIM:
List all employees workon projects where
projname = 'Alpha'
```

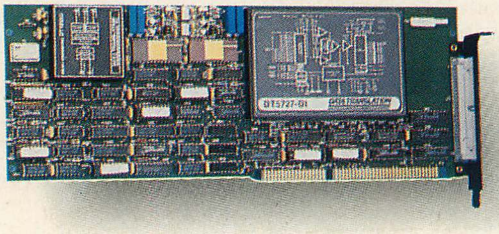
A typical SQL command and the ZIM equivalent.

ZIM is a true 4GL that integrates all necessary facilities (forms, data dictionary, update, query, report writer, debugging) into one package using common concepts. **ZIM**'s code efficiency, combined with its 4GL conciseness, make it a system that will not only significantly reduce your development time, but maintenance programming as well.

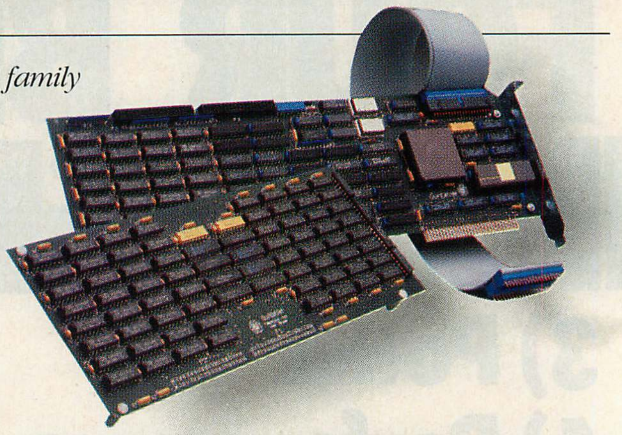
ZIM/DA (**ZIM**'s development assistant companion product) brings new depth to the concept of "productivity." **ZIM/DA** is comprised of an application generator, menu generator, interactive data dictionary, context-sensitive help and an on-line training module. **ZIM/DA** permits remarkably fast transition from prototype to finished application; a **ZIM/DA** user can generate a simple prototype in 5–10 minutes that is the equivalent of *2–4,000* lines of "C" code!

Portability Tools and applications written in any version of **ZIM** (single-user MS-DOS®, MS-DOS networks, Novell networks, QNX®, UNIX™, XENIX®, VAX®/VMS®, VM/CMS®) are uniquely 100 percent portable to and from any other supported environment. For example, a multi-user VAX application can be developed under single-user MS-DOS, since **ZIM** ports require *no code alteration.*

Hardware, software, and other developments for the IBM PC family



DT2821-G data acquisition board from Data Translation



Quadram Corporation's Quad386 XT, shown with daughterboard (front)

FROM IBM

A 1MB to 6MB **Memory Expansion Adapter**, along with the 1MB **Memory Module Kit** (composed of two 512KB memory modules that snap onto the adapter), has been announced by **IBM Corporation**. These products increase the memory on the PC/AT or XT-286 up to 6MB on one adapter. The memory modules are more densely packed, which allows a larger amount of memory per module, and thus conserves expansions slots for other functions. Memory expansion is possible without a piggyback adapter arrangement or add-on adapters. Other features include split memory addressing capability, which allows adding both conventional and extended memory to the system; a parallel printer port; and an asynchronous serial communications port. Memory Expansion Adapter with 1MB memory, $749; 1MB Memory Module Kit, $349.
IBM Corporation, 100 Summit Avenue, Montvale, NJ 07645; 800/426-2468
CIRCLE 301 ON READER SERVICE CARD

IBM has lowered the price on two models of the PC/XT and one model of the PC/AT. The price of the **XT-286** has been reduced to $3,395 (from $3,995). The XT-286 comes standard with 640KB memory, a 1.2MB 5¼-inch diskette drive, a 20MB hard-disk drive, a serial/parallel adapter, and an IBM enhanced PC keyboard. The **PC/XT Model 089**, with 640KB memory, a 360KB diskette drive, an asynchronous communications adapter, and an enhanced PC keyboard has been lowered to $2,660 (from $2,895). The **PC/AT Model 068**, with 256KB memory, a 1.2MB diskette drive, and the AT keyboard is priced at $3,395, down from $3,995.
IBM Corporation, Information Systems Group, 900 King Street, Rye Brook, NY 10573, 800/426-2468
CIRCLE 302 ON READER SERVICE CARD

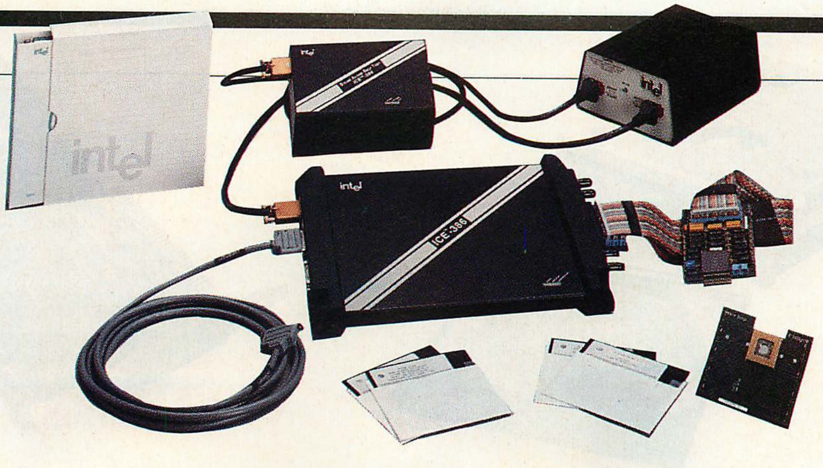
HARDWARE

Able to acquire data at a rate of 250 KHz, the **DT2821-G** from **Data Translation, Inc.** is a single-board data acquisition system with 12-bit resolution for 16 single-ended or 8 differential analog inputs; programmable gain; two 12-bit, D/A (digital-to-analog) converters; a channel-gain list; a programmable clock; and support for interrupts and DMA (direct memory access) transfers. The 250-KHz throughput rate is only available with the Compaq Deskpro 386; on the PC/AT, the throughput rate varies between 180 and 235 KHz, depending on clock speed. A/D (analog-to-digital) sampling is controlled by channel-gain list RAM. The 16-location RAM allows users to sample input channels in any sequence and at any gain. Analog output is provided by two 12-bit independent D/A converters with a throughput of 130 KHz each. The DT2821-G is supported by the **ATLAB** software package. ATLAB is a library of subroutines and supports continuous performance to memory or to disk. DT2821-G, $2,995; ATLAB, $149.
Data Translation, Inc. 100 Locke Drive, Marlboro, MA 01752; 617/481-3700
CIRCLE 310 ON READER SERVICE CARD

An 18-MHz, 80386-based microcomputer is being shipped by **Computer Dynamics**. The computer, called the **Micro System 386** (MS-386), consists of an Intel Corporation manufactured motherboard, a 1.2MB diskette drive, diskette/hard-disk controller, 512KB RAM, 220-watt power supply, and keyboard. The serial, parallel, and clock ports are incorporated on the motherboard, which leaves eight expansion slots available. Two expansion slots are 8-bit, four are 16-bit, and two are 32-bit slots that can be used for memory expansion or 32-bit I/O boards. Computer Dynamics offers a 32-bit memory expansion board with 2MB of 120-nanosecond DRAM. Available options are 40MB, 60MB, and 130MB hard disks with average access times under 28 milliseconds, an 80287-10, an enhanced graphics board and display, a monochrome graphics adapter, a 360KB diskette drive, 60MB and 120MB internal tape backups, and a second serial port. $3,295.
Computer Dynamics, One Technology Center, 2201 Donley, Suite 365, Austin, TX 78758; 512/535-3637
CIRCLE 305 ON READER SERVICE CARD

A board that delivers all the power and functionality of the 80386 to the PC/XT and compatibles is now available from **Quadram Corporation**. The **Quad386 XT** board occupies a single slot in the XT and features a 16-MHz 80386 and 1MB of true 32-bit memory using 256KB dynamic RAM (DRAM). It features 80287 support, 96KB of image memory, 32KB of direct cache memory, and disk-caching software (bundled with the board). A 2MB memory upgrade on a daughterboard is optional. Quad386 XT, $1,495.
Quadram Corporation, One Quad Way, Norcross, GA 30093-2919; 404/923-6666
CIRCLE 303 ON READER SERVICE CARD

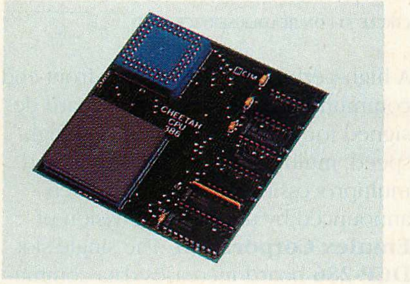
Immediate availability has been announced by **Intel Corporation** of its **ICE-386** in-circuit emulator, which provides hardware/software integration and debugging capabilities for 80386 application development. ICE-386 comes in two versions: a DOS version for the PC/AT and compatibles running DOS 3.1 or later, and a XENIX version that runs on Intel 286/310 systems. Intel's emulator supports realtime, transparent emulation of the 80386 at speeds up to 16 MHz. Other key features include 128KB of emulation memory that can be mapped in 4KB increments, full support of Intel's symbolic debugging, user-defined breakpoints of task switching, external inputs, trace buffer full, instruction execution address and data access, storage



Intel Corporation's ICE-386 in-circuit emulator

of more than 2,000 frames of program execution history with time tags for analyzing execution time of user code, support for realtime debugging of numeric coprocessors, and emulator, electrical, and timing characteristics that match those of the 80386 component. $15,000.
Intel Corporation, Literature Department, W342, 3065 Bowers Avenue, Santa Clara, CA 95051; 800/548-4725; in California, 408/987-8080
CIRCLE 304 ON READER SERVICE CARD

An 80286-to-80386 adapter board that converts an 80286-based PC/AT or XT-286 into functional 80386 ATs with a 16-



The Cheetah Adaptor/386 from Cheetah International

bit bus has been introduced by **Cheetah International, Inc**. The **Cheetah Adaptor/386** is a 3½-inch by 3½-inch translator board that mounts on the motherboard above the 80286 socket. When installed with the Cheetah Combo/70 zero-wait-state memory board, 80286 and 80386 programs run 10 percent faster. With the Cheetah Adaptor/386 and Quarterdeck Office Systems' DESQview 1.3 and Expanded Memory Manager 386 installed in an AT, users can run as many as nine separate programs concurrently. $495.
Cheetah International, Inc., 107 Community Boulevard, Suite 5, Longview, TX 75602; 800/243-3824; in Texas, 214/757-3001
CIRCLE 306 ON READER SERVICE CARD

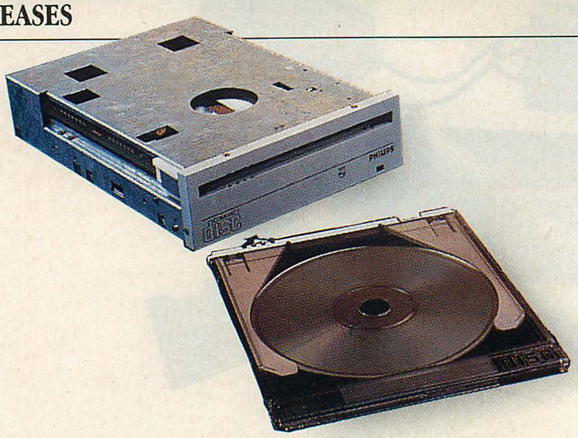
Two enhanced graphic adapters have been released by **SCOA Systems**. Both the **STAR EGA** and **STAR EGA PLUS** are compatible with the IBM EGA, CGA, monochrome display adapter, and Hercules Graphics Card. The STAR EGA displays graphics via 640-by-350 pixel resolution in 16 colors from a palette of 64. Other features include 256KB on-board DRAM, a RAM loadable character set, light pen interface, flicker-free panning and scrolling, windowing via 1-million-pixel memory, selectable 4.77- , 6- , 8- , or 10-MHz clock speed, feature connector, and an RCA video jack. The STAR EGA PLUS offers optional parallel and RS-232 serial ports. STAR EGA, under $500; STAR EGA PLUS, under $600.
SCOA Systems, 2100 Golf Road, Suite 100, Rolling Meadows, IL 60008; 312/640-8782
CIRCLE 315 ON READER SERVICE CARD

A mass storage controller chip has been announced by **Adaptec, Inc.** The **AIC-610** replaces approximately 10 logic components, including a programmable storage controller, a dual-port buffer controller, and buffer addressing logic. It is compatible with any standard interface used by Winchester disks, diskettes, and tape drives, and also can be programmed to support an SCSI (small computer system interface), IBM PC bus, or a proprietary bus. With a data transfer speed as fast as 15 MHz and a bus transfer rate as high as 1.5MB per second, the AIC-610 is intended for embedded controller applications in high-performance 3½-inch and 5¼-inch drives. The chip has fully programmable, 48-bit error checking and correction (ECC), which corrects errors up to 19 bits long. In addition, the AIC-610 offers 16-bit cyclical redundancy checking (CRC). Available in OEM quantities only. 10-MHz version, $23.00; 15-MHz, $34.50.
Adaptec, Inc., 580 Cottonwood Drive, Milpitas, CA 95035; 408/432-8600
CIRCLE 308 ON READER SERVICE CARD

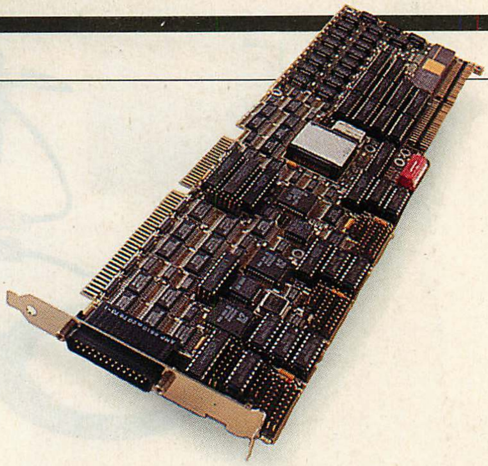
Local Data, Inc. has made available **DataLynx/3174**, a 16-port cluster controller (based on the Intel 16-bit, 10-MHz 80186) that connects asynchronous networks, PCs, terminals, and printers to IBM System/370-type mainframes. DataLynx/3174 emulates IBM SNA 3174, 3274, and 3276 control units. Offering up to 16 asynchronous ports, it recognizes as many as 32 logical units, which allows users to transfer and control 32 simultaneous data streams through its 16 physical asynchronous ports. The standard 4-port controller can be expanded in 4-port modular increments up to a maximum of 16 ports.

As an intelligent interface, upgrades are recognized when the unit is powered on without additional set-up. DCE and DTE signals are automatically recognized and selected, which allows the same cables to be used for DCE and DTE on modem and terminal ports. Users can mix and match IBM and asynchronous terminals throughout a network. DataLynx/3174 supports more than 150 asynchronous terminal types including native support for TV910, TV925, VT52, VT100, ADM3A, VT220, and Wyse 50 Plus. Operators can configure as many as six additional unique terminal drivers that are stored in nonvolatile memory (EEPROM). Both 3270 terminal emulation and file transfer are provided by TruLynx/3270 PC software. The DataLynx/3174 is a powerful protocol converter built around the same 80186. It offers dual-host support through two synchronous channels that are RS-232/V.24 compatible. 4-port version, $3,000; 16-port version, $6,500; TruLynx/3270 PC software, $195.
Local Data, Inc., 2771 Toledo Street, Torrance, CA 90503; 213/320-7126
CIRCLE 309 ON READER SERVICE CARD

A 9600-bps (bits per second), synchronous modem with a multiprotocol automatic dialer and a 25-millisecond (ms) fast training time, has been introduced



The CM 201 CD ROM drive from Laser Magnetic Storage International



Emulex Corporation's DCP-286 communications coprocessor

by **Racal-Vadic**. The **9650PA** provides four integral automatic dialers, full front-panel control, and V.29 and V.27 ter compatibility. It is targeted at twisted-pair, dial-up applications, such as micro-to-mainframe SNA and bisynchronous data transmissions, RJE (remote job entry) batch processing, and database uploads. The 9650PA operates at 9600, 7200, and 4800 bps; its integral automatic dialer supports 801-type parallel automatic calling and 3270 SDLC, HDLC, and 3780-bisynchronous serial dialing protocols. The dialing and serial command protocol is modeled around the CCITT V.25 bis recommendation for synchronous automatic dialing. $1,675.
Racal-Vadic, 1525 McCarthy Blvd., Milpitas, CA 95035; 408/946-2227
CIRCLE 311 ON READER SERVICE CARD

Incorporating the Texas Instruments (TI) 34010 graphics processor, the **Genesis 1024**, from **National Design, Inc.** is a single-slot board for fast, high-resolution graphics (1,024 by 800 pixels) with a palette of 4,096 colors. It can be used as a parallel processor and has up to 1.5MB of RAM on the card. It can run simultaneously with the IBM EGA using Genesis' EGA pass-through capability. The Genesis 1024 uses both CGI standards and GSS interface and is compatible with TI's SDB board. The TI 34010 is a 32-bit graphics processor capable of 6 million instructions per second running at 50 MHz. $1,700.
National Design, Inc., 12885 Research Blvd., Suite 105, Austin, TX 78750; 512/335-1550
CIRCLE 316 ON READER SERVICE CARD

PASSION-286 is an 8-MHz, 80286-based accelerator board from **Earth Computers**. Designed to fit in the short slot of the PC/XT, it uses a proprietary custom VLSI (very large scale integration) chip to implement a memory cache system. The PASSION-286 also provides a socket for an 80287. The board contains two switches: the first is for toggling between the 80286 and 8088, the second allows the cache to be disabled for reading copy-protected disks. $395.
Earth Computers, P.O. Box 8067, Fountain Valley, CA 92728; 714/964-5784
CIRCLE 319 ON READER SERVICE CARD

A family of half-height, 5¼-inch CD ROM drives, the **CM 200 Series** has been introduced by **Laser Magnetic Storage International**. The units are designed to access up to 600MB of digitally encoded data on standard 120-millimeter (4.72-inch) compact disks. The average access time is less than 500 milliseconds (ms), and the error-correction system provides high data integrity, with errors in data retrieval occurring less than once for every 10^{16} bits read. The drives have an MTBF (mean time between failure) rate of 16,000 hours at a 25-percent duty cycle. An audio support board that allows the unit to play audio compact disks is optional. The series includes the CM 210, a model with an embedded small computer system interface (SCSI) controller, and the CM 201, with a proprietary interface for the IBM PC. Both models are available in OEM quantities of 1,000 units. CM 210 (drive only), $500; CM 201 (drive only), $400.
Laser Magnetic Storage International, 200 Park Avenue, Suite 5501, New York, NY 10166; 212/578-9400
CIRCLE 313 ON READER SERVICE CARD

The **Everex Professional Graphics Adapter** (EPGA) is now available from **Everex Systems, Inc.** The EPGA emulates the IBM CGA, monochrome display adapter, and Hercules Graphics Card as well as the IBM PGC. Occupying one full-length slot, the EPGA is equipped with an on-board 80286 with 512KB of fast video RAM. It is an intelligent graphics controller that accepts high-function graphics commands and transforms them into colorful two- or three-dimensional images on a PGD monitor. Modeling, viewing transformations, command lists, color manipulation, and programmable text fonts are standard features. A text or graphics resolution of 640 by 480 pixels is available in 256 programmable colors from a palette of 4,096. Two- or four-color graphics of up to 640-by-200 pixel resolution can be displayed in CGA mode. High-resolution Hercules graphics are available in the monochrome mode. Both the monochrome and CGA modes include text displays of 40 characters by 25 lines or 80 characters by 25 lines. $999.
Everex Systems, Inc., 48431 Milmont Drive, Fremont, CA 94538; 415/498-1111
CIRCLE 314 ON READER SERVICE CARD

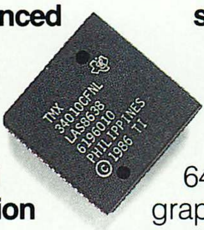
A high-performance, four-line, front-end communications coprocessor board designed for applications requiring high-speed, multiline communications, and multiprocessing capability has been announced by the Persyst division of **Emulex Corporation**. The single-slot **DCP-286** board increases data communications throughput by coupling DMA technology with an on-board, 6-MHz (or optional 8-MHz) 80286. It can support multiprotocol communications in excess of 300,000 bps via its RS-232 and optional RS-422/RS-485 interfaces. Configured for an open architecture, future boards that provide additional memory and I/O capability may be connected to and controlled by the DCP-286. The 512KB of dual-ported, parity-checked RAM (or shared memory) on the board allows the PC to directly access the DCP-286 memory. Other features include an on-board interval timer supporting three 16-bit counters, and a configurable 16KB-to-1MB shared memory window for installing multiple DCP-286 boards in a single system. $1,595.
Persyst Division of Emulex Corporation, 3545 Harbor Blvd., P.O. Box 6725, Costa Mesa, CA 92626; 714/662-5600
CIRCLE 320 ON READER SERVICE CARD

CIRCLE READER SERVICE NO. 200 FOR FACING AD

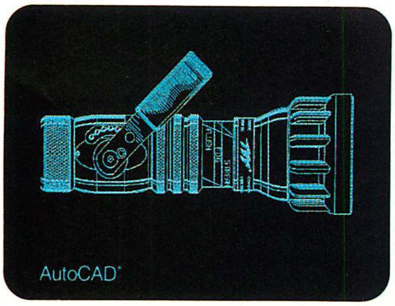
TEKTRONIX NEW ADVANCED PC GRAPHICS STANDS ALONE.

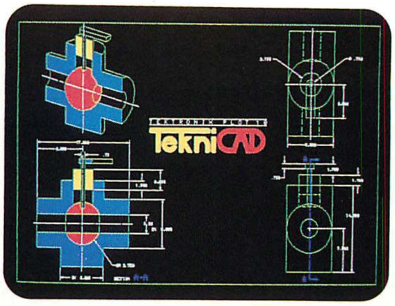
BECAUSE IT WORKS TOGETHER.

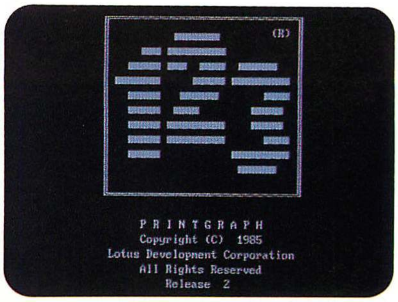
Introducing Tek Advanced PC Graphics: a fully integrated system of high-performance graphics, easy system connectivity, and unparalleled application software for your PC. Tek Advanced PC Graphics starts with a flexible multiple-rate color graphics monitor that provides 640x480 Tektronix-style graphics as well as EGA and CGA software compatibility.



Driving your monitor to a whole new level of graphics speed is Tek's PC4100 graphics coprocessor board. It features Texas Instruments® powerful TMS 34010 32-bit



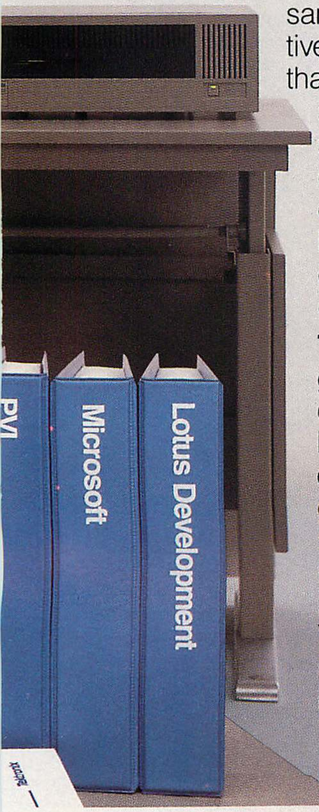




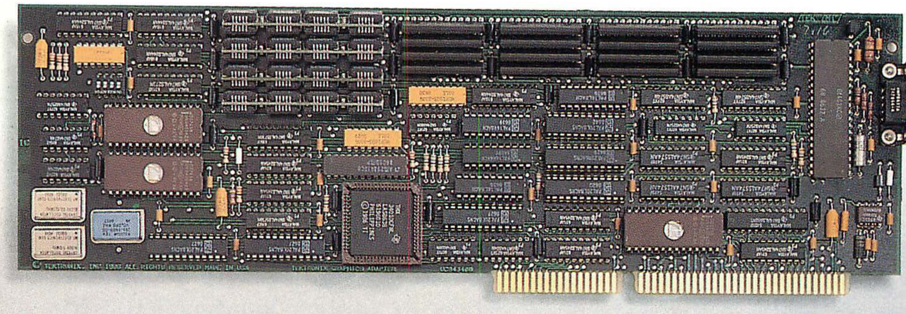
Graphics System Processor for ultra-fast throughput of your design applications. Add to that Tek's PC-05 or PC-07 terminal emulation software, and you're ready for stand-alone computing or access to a world of mainframe graphics.

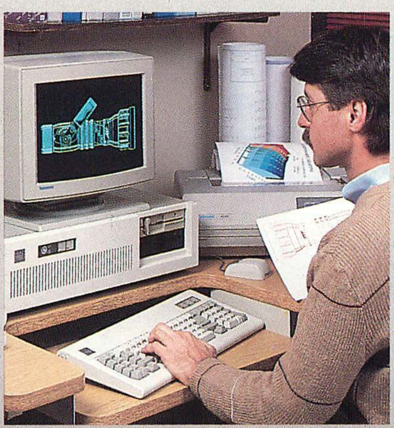
To bring those applications to life, you can connect a Tek color ink-jet printer. And start producing high-resolution, vibrant hardcopy output on either paper or transparencies.

Couple all that with Tektronix worldwide support and service, and your PC can gain the same productive advantages that host-based systems in scientific and engineering environments have had for close to two decades.



Tek's PC4100 graphics coprocessor board delivers serious graphics on a stand-alone basis. Built around the Texas Instruments Graphics System Processor(GSP),™ the graphics coprocessor board achieves a combination of sophisticated graphics and fast throughput your PC just couldn't deliver before. The GSP assumes the complete graphics processing workload, freeing your PC processor for other requirements.



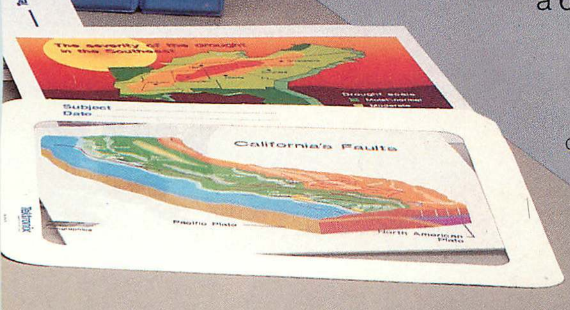


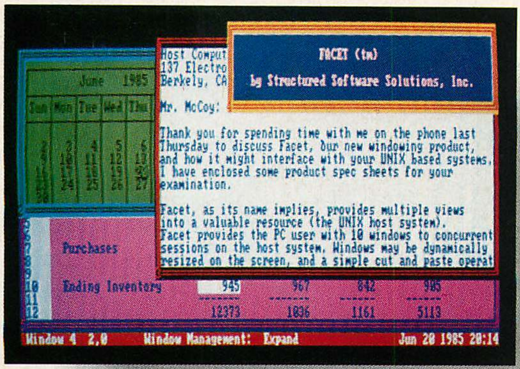
New companion monitor brings together fine detail and maximum flexibility. You'll view your applications on Tek's new multiple-rate monitor. In true Tek tradition, it provides ideally balanced, 640x480 addressability and a 60 Hz non-interlaced refresh rate. So you can use advanced packages like AutoCAD,® Zenographic's Mirage™ and VersaCAD.®

Then, to move from GSP graphics to emulation of the IBM® Enhanced Graphics Adapter(EGA) mode, you simply soft-switch. And you're ready to run the popular PC packages you probably already use in CGA/EGA mode—standards like Lotus® 1-2-3,® Microsoft® WORD® and Microsoft® Windows,® to name just a few.

Last, but not least, Tek's PC4100 links you to a world of mainframe graphics. All you do is load Tek PC-05/PC-07.

Tek PC-05/PC-07 terminal emulation software gives you mainframe accessibility with the local processing power of your PC. Because Tek PC-05 and PC-07 terminal emulation software runs under MS-DOS® 2.0 and higher, you can run your mainframe-based





Structured Software Solutions, Inc.'s FACET 2.0 menu screen

Pascal-2 compiler package from Oregon Software

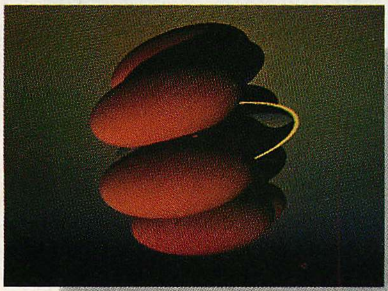
SOFTWARE

Structured Software Solutions, Inc. has announced **version 2.0** of FACET, a UNIX windowing environment that transforms an IBM PC into a windowed workstation when linked to a UNIX or XENIX host computer. FACET makes it possible for PC users to open as many as 10 individual UNIX session windows at any time on their PCs concurrently when they are running another program. It is a terminate-and-stay-resident program under DOS, that provides full-featured, host-to-terminal window management capabilities. Each FACET window on the PC emulates an ANSI terminal. FACET 2.0 operates over Ethernet networks running PC-Interface from Locus Computing. DOS version, $295; host driver, $195 to $495 (depending on UNIX host configuration).
Structured Software Solutions, Inc., 4031 W. Plano Parkway, Suite 205, Plano, TX 75075; 214/985-9901
CIRCLE 329 ON READER SERVICE CARD

Oregon Software has developed a DOS version of its **Pascal-2 compiler**, which was previously available on VAX, 68000, and PDP-11 environments. Pascal-2 generates compact code for the PC, and features a large-memory model and 32-bit integer support. Pascal-2 is certified at the highest level of the international standard. It includes a debugger, error step-through, the Intel CEL87 mathematics library, assembly language interface, execution profiler, and interface to the BRIEF text editor. $350.
Oregon Software, 6915 S.W. Macadam Avenue, Portland, OR 97219-2397; 800/367-2202; in Oregon, 503/245-2202
CIRCLE 321 ON READER SERVICE CARD

A comprehensive Common LISP system that interfaces to Microsoft C is now available from **Solution Systems**. **TransLISP PLUS** offers portability and an extensive development environment with more than 400 Common LISP primitives. Programs written carefully with TransLISP PLUS will be portable to any other Common LISP system on a micro-, mini-, or mainframe computer. The interface to Microsoft C lets a programmer customize LISP or combine C functions with LISP programs. Additional features include the integrated editor, pretty printer, trace facility, and cross reference. $195; runtime version, $150.
Solution Systems, 335 Washington Street, Norwell, MA 02061; 800/821-2492; 617/659-1571
CIRCLE 325 ON READER SERVICE CARD

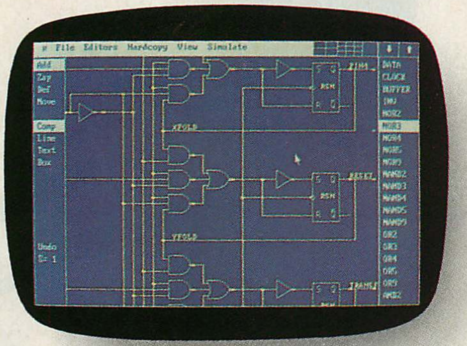
Rapid Imaging Software has released the **Imaging Toolkit**, which includes a variety of tools for image generation, processing, and display. The library of functions is compatible with the Lattice C or Microsoft C version 3.0. The toolkit's functions include image capture, contrast manipulation, look-up table mapping, noise reduction filters, histograms, convolutions, and intensity transection. A complete library of three-dimensional geometric utilities is supplied for image generation including three-dimensional geometric transformations and ray-trace illumination models. A flexible library of device interface primitives provides pixel and raster setting and vector drawing. The package also includes FFT87-2D, a high-speed, fast-Fourier transform program. $699.
Rapid Imaging Software, P.O. Box 941, Tijeras, NM 87059; 505/243-9454
CIRCLE 333 ON READER SERVICE CARD



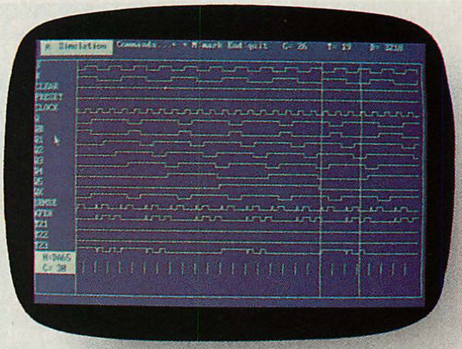
Shape produced with the Rapid Imaging Toolkit

A **Modula-2** native code compiler is available from **farbware**. This full compiler produces object files compatible with the DOS link utilities. The compiler supports the full Modula-2 language as defined in Niklaus Wirth's *Programming in Modula-2* (Springer-Verlag, 1982). The package includes a UNIX-like **make** utility as well as the complete source and object code for the runtime system. No royalty is charged for the runtime object code, and the software is not copy protected. One of the modules for which source code is provided is the low-level DOS interface module that is coded using the IBM Assembler. This module demonstrates the interface between Modula-2 and assembler code. $89.95; manual alone, $25.00.
farbware, 1329 Gregory, Wilmette, IL 60091; 312/251-5310
CIRCLE 322 ON READER SERVICE CARD

An Ada language compiler/development system has been introduced by **Meridian Software Systems, Inc. AdaVantage** implements all Ada language features, including tasking, exceptions, fixed point, generics, and separate compilation, without additional memory boards or coprocessor boards. The AdaVantage compiler is accompanied by a set of tools used to manage an Ada program library database, as well as a standard Ada library. Utility packages for interfacing to DOS, computation of transcendental math functions, and examination of the programming environment are available. $129.95.
Meridian Software Systems, Inc., 23141 Verdugo Drive, Suite 105, Laguna Hills, CA 92653; 714/380-9800
CIRCLE 326 ON READER SERVICE CARD



Spectrum Software's MICRO-LOGIC II schematic editor screen

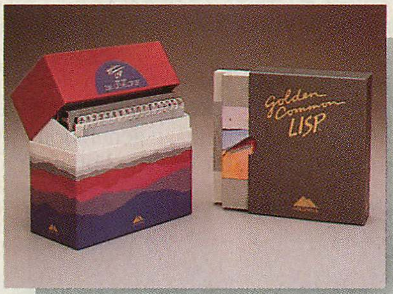


MICRO-LOGIC II timing simulation screen from Spectrum Software

MICRO-LOGIC II, an interactive design and analysis system for digital electronics, is available from **Spectrum Software**. The system includes an integrated mouse-driven schematic editor, component library editor, shape editor, data channel and clock waveform pattern editors, and a high-speed logic and timing simulator. Simulation results are displayed in a graphical form similar to logic analyzer displays. The schematic editor can handle as many as 1,000 components or integrated circuit (IC) packages per drawing. It is supplied with a library of more than 200 standard TTL/CMOS logic packages. The timing simulator can handle networks of up to 10,000 equivalent 2-input gates and features a high-speed, assembly language, event-driven routing capable of more than 1,000 events per second. $895.
Spectrum Software, 1021 S. Wolfe Road, Sunnyvale, CA 94086; 408/738-4387
CIRCLE 335 ON READER SERVICE CARD

Pick Systems has begun shipping its 10-user operating system for the PC/AT, complete with advanced virtual memory architecture and an integrated relational database. **Version 2.0** of the **Pick operating system** enhances peripheral connectivity with support for three parallel printer ports, streaming cartridge-tape units (QIC-60), serial I/O boards, and high-capacity hard-disk drives. The system is built around a dictionary-driven relational database structure; it does not limit data length and manages memory by moving from disk only data that are immediately needed rather than an entire file. Data retrieval access is performed via English-like statements. Another feature allows users to create a personalized vocabulary of terminal control language commands in place of the standard set, when desired, and Pick/BASIC includes the ability to execute those commands. For users running concurrent with DOS, sharing of a hard disk with another operating system is supported, and a utility for transferring data between Pick and DOS is standard. 10-user, $1,295; 6-user, $995; 3-user, $795; 3-user PC/XT, $495.
Pick Systems, 1691 Browning, Irvine, CA 92714; 714/261-7425
CIRCLE 327 ON READER SERVICE CARD

Gold Hill Computers has announced the **Golden Common LISP (GCLISP) 386 Developer** for the Compaq Deskpro 386. Gold Hill also announced a distribution agreement with Compaq to sell the Deskpro 386 models 40, 70, and 130. The GCLISP Developer provides



Gold Hill Computers' GCLISP 386 Developer

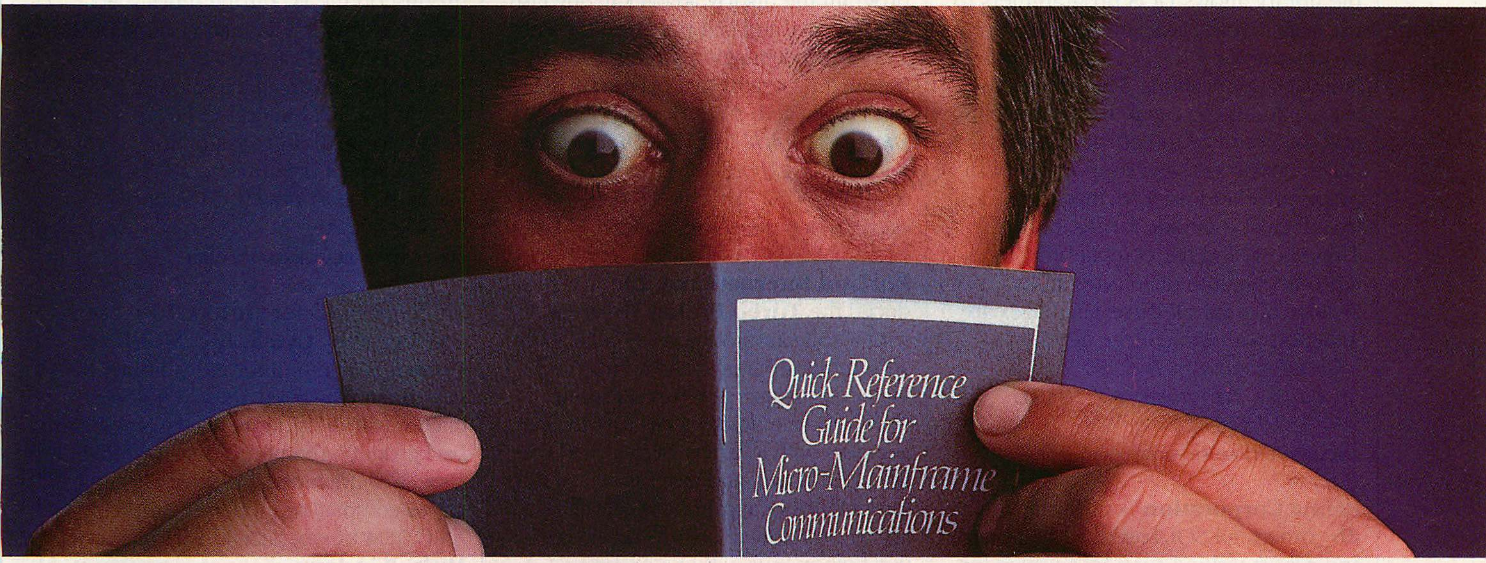
program developers a Common LISP programming environment for building expert systems and other AI applications. GCLISP can integrate C programs with AI applications. The package also supports a large memory interpreter and compiler, on-line help system, and an enhanced editor. This editor has more than 150 commands, uses EMACS keyboard mapping, and gives developers the option of defining their own keyboard mapping. The 386 Developer supports lexical scoping, packages, and transcendental functions. 386 Developer, $1,195; complete Deskpro 386 development system, $7,800 to $16,400.
Gold Hill Computers, Inc., 163 Harvard Street, Cambridge, MA 02139; 617/492-2071
CIRCLE 324 ON READER SERVICE CARD

A protected-mode, realtime, multitasking operating system that supports DOS 2.1 programs has been introduced by **Digital Research, Inc.** (DRI). Based on an earlier version of Concurrent DOS 286 and written largely in C, **FlexOS version 1.3** is being ported to a wide variety of 16- and 32-bit microprocessors. High-level language compiler support for FlexOS includes DRI's CBasic, MetaWare High C, MetaWare Professional Pascal, Ryan McFarland's FORTRAN 77, MicroFocus Level II COBOL, and an Ada/ED-C interpreter from New York University. FlexOS's graphics capabilities are based on DRI's GEM (Graphics Environment Manager) programming environment. Upgrades to version 1.3 are free to registered users of Concurrent DOS 286 release 1.2.

Available separately from DRI is **FlexNet**, the networking resource manager for FlexOS. Included with FlexNet is an electronic mail utility—a server/requester to IBM PC LAN and FlexOS functionality supported across the network. FlexOS 1.3, $750; development kit, $1,000; FlexNet, $250.
Digital Research, Box DRI, Monterey, CA 93942; 800/443-4200; in California, 408/649-3896
CIRCLE 328 ON READER SERVICE CARD

Version 2.0 of **Windows for Data** has been released by **Vermont Creative Software**. With Windows for Data, C language developers can incorporate advanced windowing, menu, and data entry capabilities into their programs. This version offers an internal debugging system that traces errors and reports memory corruption. Other capabilities include a screen layout aid, foreign language capability, multiple choice fields, scrollable subforms, free-flexibility in form and menu management. Features already present in Windows for C include pop-up data entry windows, validation and conversion for all variable types, multilevel menus, field specific

HERE'S HELP



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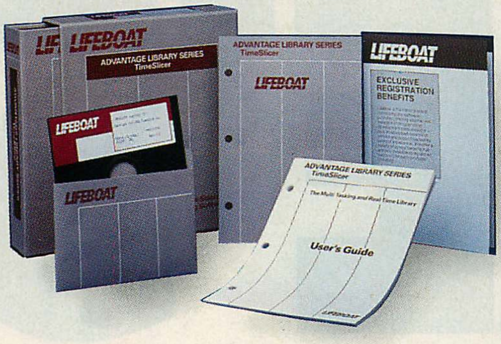

Lifeboat Associates' TimeSlicer multitasking library

db_QUERY SQL-based support package from Raima Corporation

and context-sensitive help, and full compatibility with both Microsoft Windows and IBM TopView. $295.
Vermont Creative Software, 21 Elm Avenue, Richford, VT 05476; 802/848-7738
CIRCLE 330 ON READER SERVICE CARD

Lifeboat Associates is introducing another entry in its Advantage Library Series. **TimeSlicer** is a multitasking library that allows developers of microcomputer software to offer the benefit of multitasking and realtime event processing in their applications. This linkable library allows DOS programmers to use concurrent tasks and realtime event processing for C++, C, and assembly language applications. The TimeSlicer also includes the capability for enabling tasks to optimize the efficiency of special event processing, support for both preemptive and nonpreemptive modes, two distinct methods for disabling the TimeSlicer, and the compatibility to extend the runtime of selected tasks. Header files for all three languages are included with TimeSlicer. $295.
Lifeboat Associates, Inc., 55 S. Broadway, Tarrytown, NY 10591; 914/332-1875
CIRCLE 334 ON READER SERVICE CARD

Raima Corporation is now offering its **db_QUERY**, an SQL-based, ad hoc query, and report writing support package for use with db_VISTA. Db_QUERY enables application developers to create a simple, relational view of db_VISTA's complex network database. Capabilities of db_QUERY include conditional expression evaluation, sorting formats, and support for special field types, such as money, date, and time. Db_QUERY is royalty-free and runs on DOS, UNIX, and VAX VMS systems; it is available in a source code version and for use with most C compilers. $195.
Raima Corporation, 3055 112th Avenue NE, Bellevue, WA 98004; 206/828-4636
CIRCLE 331 ON READER SERVICE CARD

VIM (for virtual machine), is a debugger from **Digital Dispatch, Inc.** VIM is an interpreter for 8088 machine code that executes in virtual memory on the PC, PC/XT, PC/AT, and compatibles. The VIM virtual debugging environment includes the entire addressing space of the processor, thus, the program under test can work with its own copy of DOS, interrupt vectors, RAM disks, device drivers, and resident utilities. VIM can optionally swap both display memory and modes at the start and end of interpretation. This allows the virtual program to reprogram the display adapter in any fashion it wants, and still provide VIM with a readable debugging screen. Even ill-behaved programs that bypass BIOS can be isolated. $69.
Digital Dispatch, Inc., 1580 Rice Creek Road, Minneapolis, MN 55432; 612/571-7400
CIRCLE 336 ON READER SERVICE CARD

Borland International, Inc. has produced the **Turbo Prolog Toolbox**, with a collection of more than 80 tools, 40 sample programs, and source code included for users of Turbo Prolog. User-interface design tools provide developers with a variety of menus (box, line, pull-down, and tree) suited to different types of applications. The Toolbox shows how to set up context-sensitive help menus within a program. Menus can be created in windows containing both text and graphic characters. The Toolbox also supplies predicates that allow the incorporation of status lines in programs being developed. Screen layouts can be designed for either the actual screen or for a virtual screen. A parser generator in the Toolbox breaks up a series or string of commands and translates it into Turbo Prolog source code. $99.95.
Borland International, Inc., 4585 Scotts Valley Drive, Scotts Valley, CA 95066; 408/438-8400
CIRCLE 332 ON READER SERVICE CARD

RPM Systems has announced **Mailman**, a fully functional electronic mail system. The Mailman user program runs on the PC and compatibles, while the heart of the multiuser system resides on an 80386-based computer. The Mailman's user interface is menu-driven, with a multilayered set of windows that show users where they are within the system at all times. Mailman can be used to send existing ASCII or binary files, but it also comes with a built-in word processor. Sending and receiving mail takes place automatically in the background on the PC during times specified by the user. Mailman is PC-Net LAN compatible and can be a node on a PC-Net LAN, or it can attach to other LANs through an RPM interface. Prices start at $2,000 for a 10-user system.
RPM Systems Corporation, 13 Corporate Plaza, Newport Beach, CA 92660; 714/720-0226
CIRCLE 337 ON READER SERVICE CARD

Three products for **Multi-C** have been announced by **Cytek, Inc. Multi-Comm** is a communications library that supports high-speed, interrupt-driven data transfers; multiple device types; and background communications by Multi-C tasks. Also included are drivers for Hayes-compatible modems and the XMODEM binary data-transfer protocol. **Multi-Windows** allows the creation of overlapping, pop-up display windows. **Multi-Forms** works with Multi-Windows to produce data entry and display screens quickly. Available for Microsoft, Lattice, and Computer Innovations C compilers. Multi-Comm and Multi-Forms, $149 each; Multi-Windows, $295.
Cytek, Inc., 805 Turnpike Street, North Andover, MA 01845; 617/687-8086
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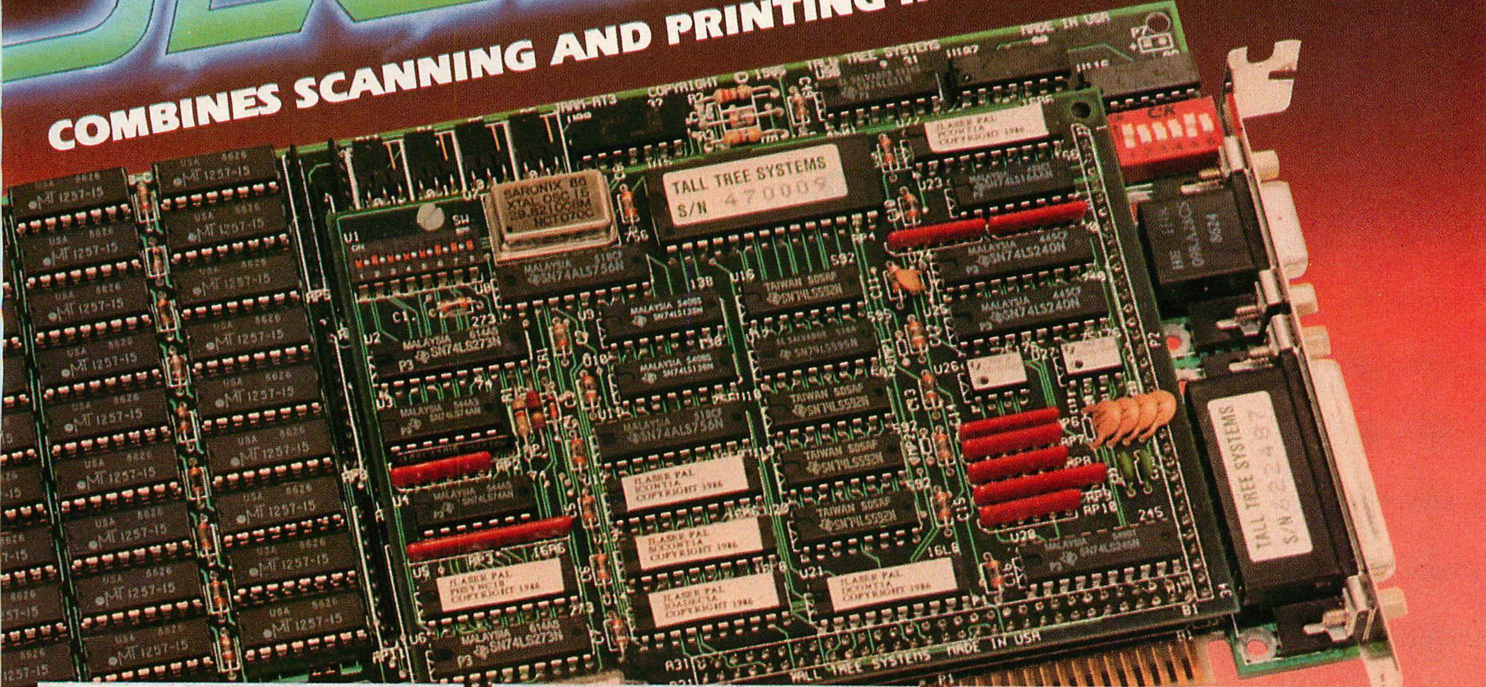

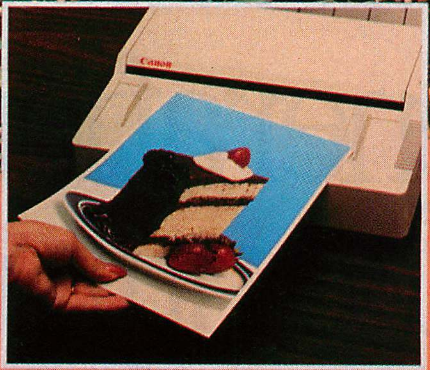

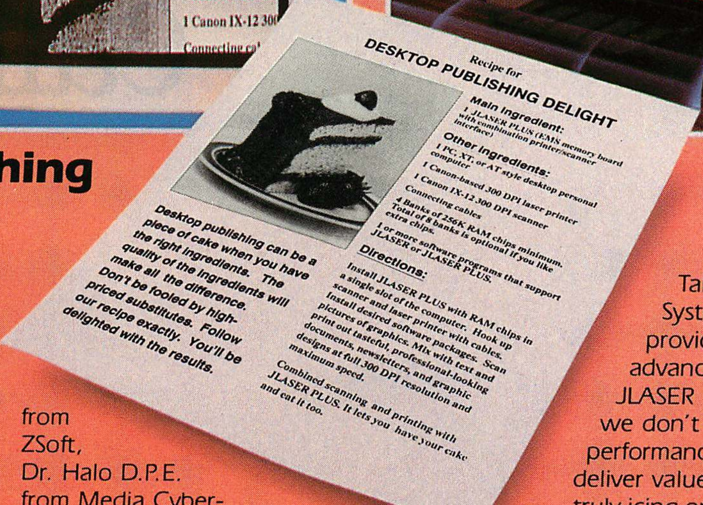

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# of 3X communications, er on the right.

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Call the people on the right and you can emulate the most terminals, including the 5250 (with all 32 display attributes) and the 3180. You can support the latest laser-jet printers, the largest range of system printers, and the most up-to-date file transfer packages on the market—even IBM's. You can do windows and cluster with three other IBM PC's from your workstation. Most important, should you ever need help, the toll-free number on the right will put you in touch with a technical support team whose sole priority is to master PC based products.

Now call the people on the left, and you can emulate some terminals, a limited number of system printers, and not all of the 5250 display attributes. Of course you'll be able to work with IBM file transfers, but once the goods are delivered, can you work with virtually no support of PC based products?

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Who should be emulating whom?

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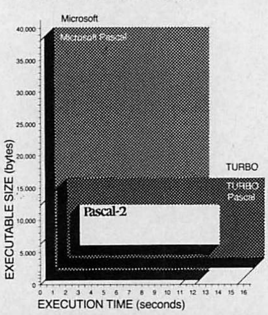
Quicksort Benchmark



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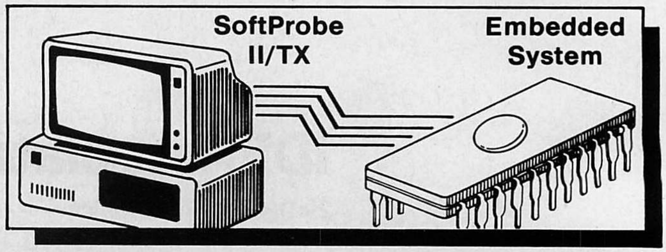
OREGON SOFTWARE

SoftProbe II/TX, a High-Level Solution for Embedded System Debugging.



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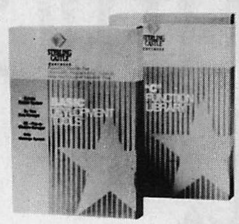
HOW TO BECOME A POWER PROGRAMMER



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TECH NOTEBOOK 75

MICHAEL ABRASH

DOS Moves on the 80386

DOS can be programmed to force 32-bit moves, thus doubling block-move performance when running on the 80386.

The 80386 is the most powerful processor on the market that features full 8086—and hence DOS—compatibility. Existing DOS programs, which were written to run on 8088- and 80286-based computers, do not exploit its features, and in general, they benefit only from the greater speed of the 80386. DOS programs, however, can be written to take advantage of the 80386, and, at the same time, also work on the PC/XT and PC/AT. One example is the moving of blocks of data from one area of memory to another.

The 80386 is inherently capable of reading or writing 32 bits of data at a time, and the 32-bit form of the MOVS instruction can move a doubleword from one memory address to another in only seven cycles, memory performance permitting, of course. Unfortunately, MOVSW instructions performed in a DOS-compatible mode of the 80386 (real or virtual-8086 mode) default to moving only 16 bits at a time. A special prefix can be used to force 32-bit moves, allowing DOS programs approximately to double their block-move performance when they are running on an 80386.

The subroutine FastBlockMove in the listing below (FASTBLK.ASM) performs a block move in units of either 16 or 32 bits, as selected by the calling program. The key to this subroutine is the 66H prefix to the REP MOVSW instruction; this prefix forces the operand size of the following instruction to 32 bits. In the case where a 16-bit move is requested, the subroutine simply jumps directly to the REP MOVSW and executes the block move without the prefix, so the default 16-bit move is performed. For moves of both sizes, the count in CX, which is originally in bytes, is divided down to match the number of words or doublewords that are to be moved.

The 80386 performs best when it is using 32-bit operands that are doubleword-aligned—that is, at addresses that are multiples of four. FastBlockMove assumes that both the source and the destination blocks start on doubleword boundaries. With any other alignment, no performance gain is achieved over moving 16 bits at a time. Likewise, blocks that are moved by words should start on word boundaries in the ATs. The routine automatically handles block sizes that are not integral multiples of four bytes (for 32-bit moves) or two bytes (for 16-bit moves).

FastBlockMove can be used "as is" by a program that first determines whether an 80386 is installed. The processor-specific approach can be integrated readily into the main program more tightly for performance reasons. For example, a program could have separate 16- and 32-bit block-move subroutines, and at start-up could set a vector to the appropriate subroutine; the vector would then be used throughout the program to invoke the appropriate procedure without further testing. However it is done, the key point is that with some clever programming, even DOS programs can take advantage of some of the enhanced features of the 80386.

Michael Abrash is a senior software engineer for Orion Industries. He is coauthor of the book, Graphics for the IBM PC.

LISTING: FASTBLK.ASM

```
; Fast (32-bit) block move for 80386 computers.
; Calling program selects 16- or a 32-bit move.
; Calling program must be sure 80386 is present for 32-bit move.
; For best performance, source and destination blocks should begin on
;  doubleword (for 32-bit move) or word (for 16-bit move) boundary.
; Automatically handles block sizes with odd words and bytes.
; Input: DS:SI = source.
;        ES:DI = destination.
;        CX    = number of bytes to move.
;        AL    = 1 to perform fast 32-bit move (for 80386 only),
;                0 to perform standard 16-bit move (for 8088/86/286).
; Results:
;  CX & BX destroyed, SI points to the byte after the end of the
;  source block, DI points to the byte after the end of the
;  destination block, direction flag cleared.
;
cseg    segment word public 'CODE'
        assume  cs:cseg
        public  FastBlockMove
FastBlockMove   proc    near
        cld
        xor     bx,bx   ;clear odd-size flags
        shr     cx,1    ;convert move size to words
        jnc     CheckFor32BitMove
        mov     bl,1    ;indicate odd byte
CheckFor32BitMove:
        and     al,al   ;has caller requested a 32-bit move?
        jz      DoBlockMove
        shr     cx,1    ;32-bit move -- convert to dbl words
        jnc     Do32BitMove
        mov     bh,1    ;indicate odd word
Do32BitMove:
        db      66h     ;prefix to make the default size for the
                        ; following instruction 32 bits.
DoBlockMove:
    rep movsw           ;move the block -- the move normally defaults
                        ; to 16 bits at a time, but if the size
                        ; prefix was executed, 32 bits will be
                        ; moved on each iteration
        and     bh,bh   ;is there an odd word?
        jz      TestOddByte
        movsw           ;if so, move it
TestOddByte:
        and     bl,bl   ;is there an odd byte?
        jz      Exit
        movsb           ;if so, move it
Exit:   ret
FastBlockMove   endp
cseg    ends
        end
```

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Plink86*plus* is the only linkage editor containing advanced overlay capabilities. It handles any compiler or assembler producing standard Intel or Microsoft OBJ files, including COBOL and FORTRAN, Lattice C, CI C-86, Microsoft/IBM languages, and mbp/COBOL. Virtual memory management ensures ample capacity for symbol and common block names (35,000). Plink86*plus* supports an unlimited size file, an unlimited number of modules and up to 4,095 overlays nested up to 32 deep. Merges object modules, caches overlays in extended or expanded memory, and automatically reloads overlays upon function return. Includes Plib86 object library manager.
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Plib86 is an object module librarian for Microsoft and Intel format object modules and libraries. With Plib86, you can add, delete or extract modules to or from libraries, and explode a library to its component modules with one command. Plib86 also produces program cross-reference listings in various formats to a disk file, screen or printer.

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Ptel

A Pfantastic communications program for use with most popular modems such as Hayes and compatibles, DEC, Racal Vadic, Anchor, US Robotics and Novation. Ptel automatically adapts to Telink, XModem, Kermit or Modem 7 for CRC checking and for ufn and afn (i.e. "wildcard") file name list transfers, if the bulletin board or the other end computer supports them. With Telink, you'll even get a forecast of file transmission time, always useful in controlling telephone expenses.

In addition to saving received files, Ptel can create and save a transcript of the session commands and messages.

Highly configurable, with choices temporary or saved as altered defaults. Unique telephone directory of bulletin boards and other services, allowing access by service name. Ptel runs fully interactive or can be batch driven from a script. You can even exit to DOS move files around or run another application and then return to Ptel, all without dropping the line.
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Pfinish™

Pfinish helps to "fine-tune" a software product by identifying inefficient or unnecessary sections of code that need to be rewritten for maximum performance. It analyzes your program during execution, producing reports and histograms that give a snapshot of which routines were reached, their callers, how many times each is executed, how much time is spent in each, how many instructions are executed in each, and more. Histograms and tabular reports, sorted by address or symbol, may be written in any page width or height, to a file, the console, or the printer. Pfinish, unlike other "profilers", can use symbol table information to produce much more meaningful analyses on overlays and interrupts.
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Pdisk is a complete disk management package that includes advanced Backup/Restore, Tree Management and Disk Cache utilites. Menu, command line or file-driven. Many options permit backup/restore inclusions/exclusions, whole and partial subdirectories, backups by date/time, file type, and backups of all files or files changed since last backup. It can also maintain a log of backups. Supports AT high-density floppies, PC floppies, and any storage device accessible through a device driver. Tree-oriented Directory, Delete, Copy, Compare, and Remove-Directory simplify management of complicated subdirectory structures. CACHE significantly speeds up disk operation on PC/XT/AT by keeping data in memory instead of disk. In addition, CACHE is compatible with the Lotus-Intel-Microsoft (LIM) expanded memory specification, as well as extended memory.
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Pfix™ 86*plus*

Pfix86*plus* is an easy to use, menu driven, multi-windowed symbolic debugger that works with any IBM or Microsoft compiled language. Pfix86*plus* accesses the full symbol table provided by MS Link or Plink86*plus*, and automatically handles Plink86*plus*-overlaid or resident programs. Source code, assembly language translations, stack, data areas, and breakpoints are displayed simultaneously. Features include: In-line assembler for temporary patches, temporary and permanent breakpoint settings, full speed or trace modes, user-assignable variables, dual-monitor support, up to 100-step traceback, debug log to disk or printer, synchronized source file display, breakpoints in source code, disassembly to disk, configurable menus, multiple code and data windows, and keystroke macros.
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PforCe is a pre-coded optimized object-oriented toolkit of over 400 routines for C programmers. It includes data bases with B-trees, windows, interrupt-driven communications, string handling, menus, all of the basic DOS interfaces, and a complete set of low-level functions to interface directly to the hardware. PforCe comes complete with indexed reference manual, on line resident help, and quick reference card. It supports all memory models of the following C compilers: Lattice, Aztec, Microsoft, CI-86, and Wizard. PforCe includes full source code and there are no royalties on generated applications using the libraries. A demonstration diskette is also available.
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Brief has text search abilities rivaling "grep", with wildcards for matching, indifference to intervening characters, acceptance of character ranges.

If you use Lattice, C86™, or Wizard, and have 320k, you can compile your C program without ever leaving Brief. It finds the lines with errors, and marches you through the text for repairs.

Parts of Brief were written with its own Lisp-like macro language which has structure, 32-character variable names, conditional execution, loops, and you can actually read it! Nothing like the hieroglyphs we've seen elsewhere. Bulletin board and public domain disks with macros. "Simply the best text editor you can buy". Dvorak *Infoworld*. (Needs 192k.)

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U0590	**$195**	**Call**

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WINDOWS for C/WINDOWS for DATA *Microsoft Windows™ and TopView™ Compatible*

Windows for C™ is a library of over 80 functions to add the pizazz and practicality of window partitioning to your application. Unlimited windows, each defined in a C structure for easy reference throughout your program, can be made either to pop up or permanently overwrite the screen. Routines will scroll and highlight lists with arrow keys, will read and scroll ASCII files vertically and horizontally in windows, and even write to memory-loaded files off the screen.

Logical treatment of video attributes permits unchanged programs to run on color or monochrome. Colors of windows are set individually.

All functions are in separate modules; only those used are linked. Only buffers holding on-screen or temporarily obscured windows occupy RAM; others released dynamically. Best overall rating and fastest display in Bill Hunt's 7/85 *Tech Journal* review of five windowing products.

Windows for Data comprises all of Windows for C but takes in data through the windows as well. At the high level a single function lets you specify prompt string, field length, data type, screen location, picture, target variable, then sets lesser functions scurrying to get and process a user's input. There are utilities to get system date and time, mess with strings, create your own masks for fields.

Field options can require entry, prevent entry, permit insert or overtype, beeping on invalid or overflow keystrokes, and attachment of field-specific help messages and functions you want called to display messages or validate entries. And you decide which keys will clear a field, jump to the next or prior, quit, etc. Options diverse enough that a set of "fields" can be made to behave like a Lotus™ menu.

Specify Compiler:	List:	PC Brand:
T0100 Windows for C	**$195**	**$149**
T0150 Windows for Data	**$295**	**$259**

MICROSOFT C 4.0 *A Great C Battle Rages and You're Winning*

As the dreadnaughts pound each other with ever heavier ordnance, today's programmers reap the spoils of this war. Bundling a source debugger and a "make", and sporting a "huge" memory model permitting single data objects larger than 64k, the Microsoft C compiler has jumped a full version number to 4.0. But what's really impressive are the benchmarks reported in Dr. Dobb's (8/86) encyclopaedic survey of 17 C compilers. Microsoft's and IBM's C (licensed from Microsoft) run away with the contest winning 11 of 27 benchmarks.

The CodeView™ debugger, free for a limited time, uses windows to show everything on one screen: source alongside disassembled object, variables, stack and registers. Drop down windows—use a mouse if you like—obviate learning of commands. "A source-level debugger that puts the rest to shame" (Dobb's).

Microsoft C now has five memory models for code and data, plus non-library support for another thirteen, and boasts alternate math packages for speed versus accuracy, with or without 8087/80287 chips.

Both linker and library manager are part of the package, as is the "make", a UNIX™ name for a smart batch program which knows to expend minimum effort to rebuild any size of project by compiling and assembling only elements affected by new or changed modules.

It is reportedly used by Lotus, Ashton-Tate and, fittingly, Microsoft itself to develop Windows. Dobb's calls it "the best MS-DOS C development environment value today [for] virtually any kind of program conceivable." 320k suggested.

Ask for:	List:	PC Brand:
G0500	**$450**	**$295**

C-TREE & R-TREE *B-Tree File Manager Now Has Report Generator*

c-tree: The only major b-tree file manager that comes with built-in network support rather than a costly separate version, c-treeTM is sturdy code that has weathered many seasons of prolonged and widespread use. It comes in C source, so you can modify it to fit a special case; permits any number of keys for a data file—alpha, numeric, even floating point; handles files with varied record lengths; and multiple keys in one index file. In short, you get the works—and there are no royalties.

C-tree's design splits nodes to allow any number of users to access an index file simultaneously even when updates are in progress. So multi-user configurations and adaptation to networks are possible. Record-locking routines are provided for DOS 3.x, UNIX, XENIX.

C-tree can travel. Tests in many environments prove that c-tree gives your application a ticket to anywhere.

r-tree: thousands of c-tree users (and you) now have a suddenly expanded ability to produce ad hoc reports from files maintained by c-tree (v.4.1E or later), side-stepping the elaborate C coding usually entailed.

Once you link a description of the field characteristics of the data files to the r-tree library, you are free to use an ordinary text editor to write any number of report scripts with no further C coding. Reports can access data in several files, select to match complex searches, join the findings into new logical records, sort them, calculate new fields and columns, tabulate by any number of control breaks. Your script files show visual representations of report images—not just rows and columns, but customized layouts.

r-treeTM comes in source code and is designed for the same portability c-tree brings you. Fits any compiler.

	List:	PC Brand:
c-tree: F0660	**$395**	**$329**
r-tree: F0665	**$295**	**$245**
Combined: F0664	**$650**	**$541**

dBC *Lattice Library Maintains dBASE Compatible Files With the Power and Speed of C*

dBC™ links C to dBASE. It creates and maintains files and their indexes which exactly replicate dBASE file design. So dBASE can read and update them. And the reverse. dBC can use any files created by dBASE. Now C and dBASE can operate on the same data bases interchangeably.

That opens up the widespread culture of dBASE installations to exploitation by C programmers. Tap that market, avoid the resident dBASE language, and gain the advantages of C with this single product.

dBC's functions parallel all dBASE's file handling commands, many decomposed to give closer control. Each backed by demo source files on disk.

Use dBC for custom work for clients, or on its own. It's a complete ISAM file manager for C whether or not dBASE will be used in tandem, supports all four memory models, and can have sixteen index and data files open. Big discount to buyers of both dBASE II and III versions. Specify Lattice, Microsoft 3.x, or DeSmet.

Versions:	List:	PC Brand:
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DAN BRICKLIN'S DEMO PROGRAM

Storyboard Your Program

The Legendary One has created Metaphor Two when the rest of us are still on Zero. Dan's first was the original electronic spreadsheet (VisiCalc™). This one is for programmers.

Words don't express program ideas because programs are screens! Dan's Demo creates slide shows. Create a screen — a snapshot of your planned product as it runs. Anything goes: words, borders, box rules, inverse and underlining of monochrome, fore- and background color. Copy this "slide" to an empty screen. Change it a little, to show the next instant of run-time. Do it again. Presto, a whole slide show of your program in action.

All 250 characters and attributes are available from scrollable lists which pop to the screen. All commands are layered in Lotus-style pop-up menus. Frequent choices mapped to function keys as well. 80x25 character mode, not bit-mapped.

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Invaluable to prototype the program you are about to write, to position the labels, choose the color decor, smoothe out the keystroke interface. Or load the "capture" utility and snapshot the screens of any running program for an instant slide show.

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Translates BASIC Into C

For a trifling price, BASTOC™ moves truckloads of BASIC code over to C. It's a translator which takes in Microsoft Extended BASIC and emits pure K&R C for Lattice 3.0. It will optionally convert your program into a single monolithic C function or decompose it into separate functions, one for each GOSUB label.

Version 2's optimization dramatically reduces execution time. Converts to integers those variables in BASIC programs which do not need floating point. Where BASIC uses full assignment statements to increment counters, BASTOC converts to C's compact form. Strings dynamically allocated ridding your application of BASIC's catatonic halts for garbage collection. Creates structure of even convoluted BASIC code. Huge worksaver.

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S0375	**$495**	**$399**

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Supports up to 9600 baud, ASCII or binary, any parity or word length, 8250 UARTs, Xon/Xoff and Xmodem, WideTrack receive. Specify: S0750 & Compiler. List: **$185**, Us: **$139**

INTERACTIVE-C

Compiler-Compatible Interpreter, Editor, Debugger

Earlier C interpreters were miraculous compromises. Interactive-C shows how far C interpreters have come. More than an interpreter, Interactive-C is a fully-integrated development environment: a complete K&R interpreter bound tightly to its own editor and debugger.

Slice through programming projects like a hot knife through butter. Extensive error-checking insures immediate detection of program misbehavior. State of the art debugging tools include breakpoints, watchvalues, several stepping options and interactive viewing and modification of variables. An Interactive-C exclusive lets you interrupt to edit and "continue" from where you left off. Eliminates plodding replays of already debugged code—the ball and chain of other interpreters.

Operate Interactive-C using adjustable edit, command, and status windows. Toggle a second screen showing only your program's output—never any crowded intermixing. Or, boost productivity with twin CRTs. Load object code of functions you have already compiled. Or of commercial libraries. Interactive-C has immediate mode, syntax checking both as you type and run, and cursor positioning precisely pointing at an error, not possible with incremental or pseudo-compilers which leave source code behind.

100% compiler compatible—right down to header files and library calls. Port programs between Interactive-C and your compiler with no modifications whatever— not even tricky areas of dynamic memory allocation and I/O.

Specify:	List:	PC Brand:
E950 & Compiler	**$249**	**$219**

Shopping List for the Power Workbench

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ASSEMBLERS & DEBUGGERS		
Advanced Trace-86 *Morgan, ASM Interpreter*	175	119
Codesmith-86 *Dubugger by Visual Age*	145	99
CSD Debugger *C source level by Mark Williams*	75	55
C-Sprite Debugger *by Lattice, source level*	175	139
Microsoft Macro Assembler *with Utilities*	150	109
PASM86 *by Phoenix, Macro Assembler*	195	125
Periscope I Debugger *Data Base Decisions*	295	235
Periscope II *Data Base Decisions*	129	99
Periscope II-X *software only*	115	74
Pfix86 Plus *by Phoenix, Symbolic Debugger*	395	235
BASIC LANGUAGE		
BetterBASIC *Summit Software*	195	165
8087 Math Support	99	85
Btrieve Interface	99	85
Run-Time Module	250	225
Microsoft BASIC Interpreter *for XENIX*	350	295
Microsoft QuickBASIC Compiler *full BASICA*	99	79
Professional BASIC *by Morgan*	99	69
True BASIC *True BASIC Inc*	150	99
Run Time Module	150	99
C COMPILERS		
C-86 Compiler *Computer Innovations*	395	289
Lattice C Compiler *from Lattice*	500	299
Let's C Compiler *by Mark Williams*	75	55
with CSD Source Level Debugger	125	90
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"Compiler's documentation, ease of use, speed of execution, and debugger facilities place it first for recommendation" said the *Tech Journal* (10/85).

R-M has been writing FORTRAN compilers for IBM, DEC, etc. for 20 years. There is no greater expert.

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Lattice 3.0 defaults to the ANSI proposed standard when you need strict adherence, but command line options restore leniency. And it adopts ANSI checking of external function arguments by data type to kill bug swarms when modules join up at link time.

Lattice now delivers smaller .EXE files, boasts very fast link times and a more efficient aliasing algorithm. New options generate code to use 80186 and 80286 features; 8087 of course sensed and utilized. Lattice has enjoyed pre-eminence so long that developers have created far more snap-on tools for Lattice C than any other compiler. William Hunt's *PC Tech Journal* review of 12 compilers awarded Lattice the only "very good" rating for add-on library availability.

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	List:	PC Brand:
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C Tools	**$125**	**$ 84**
C Tools 2	**$100**	**$ 67**
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Dialects of dBASE

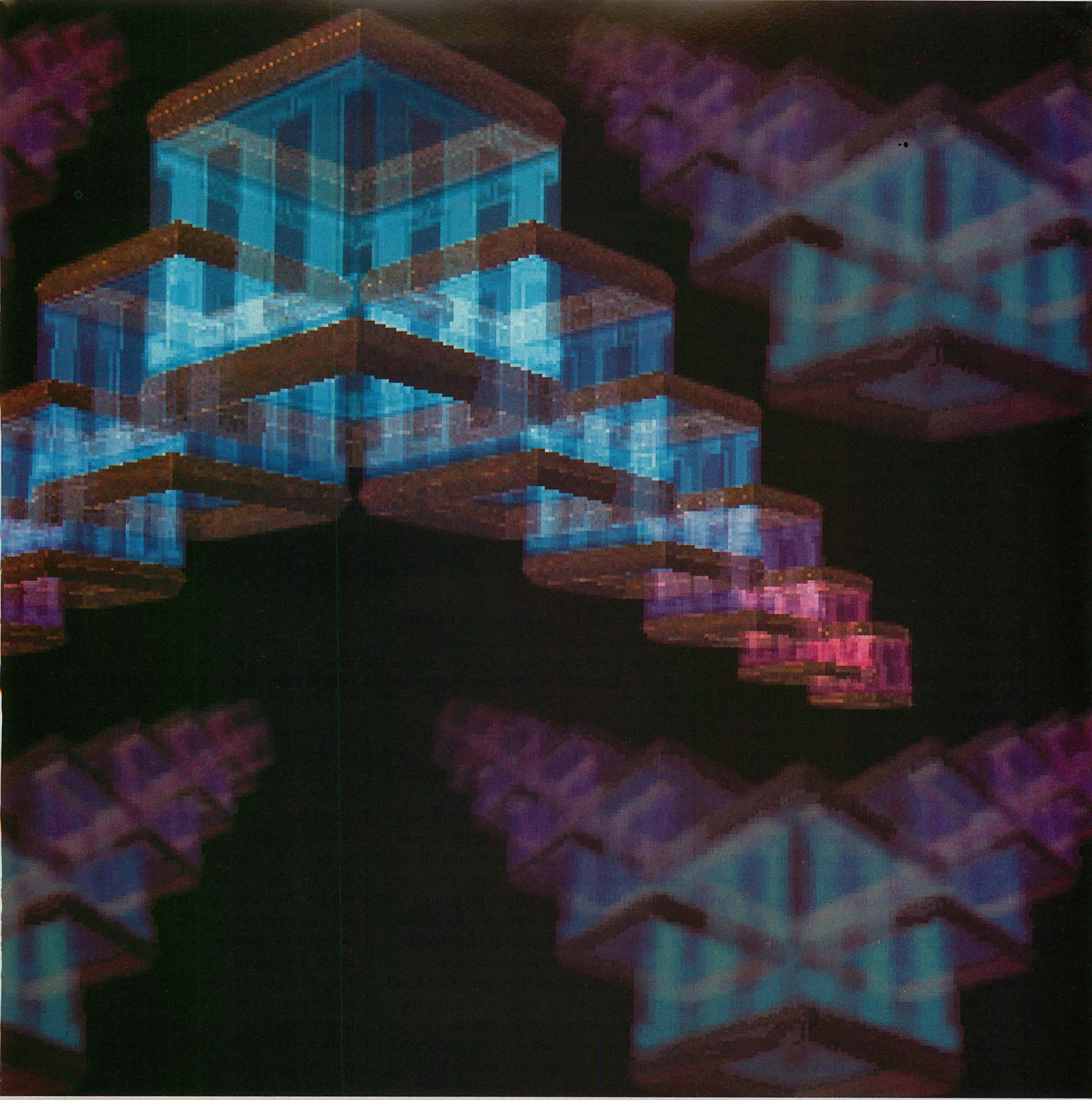
TED MIRECKI

Ashton-Tate's popular dBASE III has inspired the creation of compilers to enhance the language aspect of this database manager. Three quality products are considered here.

Although never formally defined as a programming language, dBASE III has all the earmarks of one. In terms of popularity it is more successful than many languages with blue-blooded pedigrees, written in Backus-Naur notation. Thus, it is not surprising that dBASE III has acquired that accoutrement of a true language, the compiler. Although none is available from Ashton-Tate, others have filled the gap. The three reviewed here are: Foxbase+ by Fox Software, Clipper by Nantucket Software, and Quicksilver by WordTech Systems.

The lure of a compiler, of course, is the promise of execution speed that cannot be matched by an interpreter. Users familiar with the 10- to 20-fold improvement that a BASIC compiler gives over the BASICA interpreter might expect a similar improvement from a dBASE compiler. But in the case of a database manager, the gain from compilation is not as great as that for a compute-intensive language such as BASIC. The main reason is that the database manager spends relatively more time reading disk files than reading the source code. If in a particular process the interpreter spends, say, 50 percent of its time waiting for disk I/O, the overall speed of the process cannot be speeded up by compilation by more than a factor of 2, no matter how much faster the compiled code is on the other 50 percent of the processing.

Another reason for the relatively small difference between compiled and interpreted dBASE code is the inherent efficiency of the dBASE language. A single statement, once interpreted, can trigger a massive amount of processing without further intervention from the interpreter. For example, when performing a sort, the interpreter need parse only the SORT statement itself, then turn control over to a canned routine. The time spent parsing and recog-



nizing that one statement is insignificant compared to the time spent executing the sort routine. Assuming that this routine is already executed from native code, the time for completing the sort would not change noticeably even if the time of interpretation could be totally eliminated. In fact, if a compiler implements a less efficient sort algorithm than the interpreter, the total elapsed time may well increase after compilation—as was observed in several of the tests performed for this article.

This does not mean that dBASE compilers are not useful. Even with the fourth-generation power of the language, many operations still must be coded in detail. Screen display, input validation, and calculation with memory variables can all benefit from compilation. In particular, the user will experience a perceptible improvement in response time if the processing of screen I/O can be speeded up.

But in the world of commercially distributed applications, a compiler addresses two important issues besides speed. The first is source code security. Whether it compiles to native code or to some intermediate form of pseudocode, a compiler protects the programmer's methods and algorithms from unintended viewing and prevents errant (or even beneficial) changes.

The other issue is the cost of licensing end users. When source code is distributed, every copy of an application requires a copy of dBASE III to execute it. This cost, when added to the cost of the application itself, may price the product out of reach of many potential clients. Even in a corporate environment, where a central group develops programs for distribution throughout the organization, providing a copy of dBASE for every machine that needs to run a dBASE program may not be economically justifiable.

COMPUTER GRAPHIC • DOV JACOBSON

A compiler, on the other hand, is typically sold with a license for unlimited distribution of end-user applications. Each copy of a compiler entitles the developer to sell an unlimited number of copies of a program, and each such copy runs without needing a copy of dBASE or of the compiler. If the finished application needs to be executed by a runtime system, such a system may also be obtained with an unlimited distribution license. Therefore, despite the relatively high initial cost of a compiler, a major consideration in using one is the cost savings from buying a copy of the compiler for each development machine, as opposed to buying a copy of dBASE for each end user system.

The design of a dBASE compiler involves several choices. The first is whether to produce stand-alone native code or semicompiled pseudocode. As will be shown, the former does not necessarily yield a performance advantage over the latter.

Another choice the designer makes is which mode of dBASE to support. Ashton-Tate's product is really meant to perform two functions. One is that of an interactive data entry and query environment; the other that of a traditional programming language. The dBASE III programming language functions are used far more than the interactive data entry and query functions. Many users execute applications, preprogrammed by others, without an awareness of the capabilities of the language that are not used in the particular application. Because of its prevalence and because this matches the traditional usage of other compiled languages, dBASE compilers typically have supported only this mode of operation.

But increasingly, sophisticated end users are discovering the full power of dBASE III and are beginning to use it in the interactive mode. They are also writing programs, but these are usually of an ad hoc, informal nature rather than the polished efforts of the professional programmer. The situation with these dBASE users is similar to that of the expert spreadsheet users, in which macro programs are written to support a primarily interactive mode of operation. Here, too, a compiler can help.

Both modes of dBASE use are covered among the three products that are reviewed here. Clipper and Quicksilver address only the preprogrammed mode of dBASE, while Foxbase+ attempts to improve on all areas in which dBASE can be used, including interactive processing. The compilers' features are compared in table 1. In that table, each

TABLE 1: *Compiler Features*

	FOX	NANTUCKET	WORDTECH
PRODUCT	Foxbase+	Clipper	Quicksilver
VERSION	1.2	Autumn 86	1.0c
PRICE	$395	$695	$599
NETWORK CAPABILITY	$995[a]	Included	Add. $99
NATIVE/INTERMEDIATE CODE	Int.	Native	Both
LINK STEP NEEDED	○	●	Two
STANDARD DOS LINKER	N/A	●	● 1st step ○ 2nd step
LINKER SUPPLIED	N/A	●	● 1st step ○ 2nd step
USE dBASE INDEX FILES	○	○	●
SIZE			
Number of disks	2	3	8
Number of files	4	9	25
Total file size	632KB	461KB	1,250KB
SYSTEM REQUIREMENTS			
Free memory	375KB	200KB	256KB
Earliest DOS version	2.0	2.0	3.1
Uses 8087	●	●	○

● = Yes ○ = No
N/A = Not applicable
[a] Total cost for version with network capability.

Clipper and Foxbase+ produce native and intermediate code, respectively. WordTech's Quicksilver attempts to provide the best of both worlds by producing both.

compiler's memory requirement is the minimum free memory above DOS and other resident programs, that is, what is reported as memory available by CHKDSK. The compiler's total file size includes the compiler itself, the linker (if supplied), the debugger, and all libraries and object code modules. Standalone utilities and sample programs are excluded. The following is a look, first at each compiler's individual installation, operation, and documentation, then at the three as they compare head-to-head in various aspects of their implementation and performance.

Fox Software. Foxbase+ is the closest of the three compilers to dBASE, and it is, in concept, different from the other products reviewed. Besides being a compiler, or at least a pseudocompiler, it is also a full dBASE III work-alike, implementing almost all of the interactive features of the Ashton-Tate product. Although not a true compiler, it is included in this comparison for two reasons: it implements the most dBASE features, and it far surpasses the others in speed of both development and execution. As amazing as it seems, Foxbase+ pseudocode runs faster than the native code of either Clipper or Quicksilver, and its file operations match or surpass dBASE III Plus in speed. To keep the comparison meaningful, the emphasis will be on how Foxbase+ compiles and runs prewritten programs, not how closely its interactive features mimic the corresponding features of dBASE III. Suffice it to say that the capabilities and user interface of Foxbase+ are close enough to those of dBASE III Plus that for all practical purposes, the two are functionally identical. The plus sign (+) on the product's name identifies this version as compatible with dBASE III; the original Foxbase without the + is a dBASE II work-alike and is still available.

The installation of Foxbase+ is somewhat similar to that of the latest unprotected version of dBASE III Plus. Although the distribution disks are not copy protected, the main Foxbase+ file cannot be executed until it is activated with a serial number and password. The product comes with two passwords: one in a sealed envelope, the other open. The latter activates the demonstration mode, which limits Foxbase+ to working with databases of no more than 120 records. The user may test the product in this form and return it for a refund if it proves unsatisfactory, provided that the password that activates the production version remains in its sealed envelope. If the user decides to keep the product, he opens that envelope and repeats the activation procedure with the new password found there. All files, however, may be backed up both before and after activation.

Installation is completed by copying the activated main file and its overlays and other auxiliary files to working disks or directories; a batch file that automates this function is provided. Running Foxbase+ from diskettes, although somewhat cumbersome, is quite possible and is much more practical than running the other compilers or dBASE III itself on such a system.

The Foxbase+ compiler produces intermediate pseudocode in files with a .FOX extension. It can process a series of source files at one invocation; the list of files must be given on the command line that invokes the compiler. Each input file produces a separate .FOX file. The compiler assumes no default extension for source files, so the .PRG extension on those files must be specified for each file name. However, as compensation, the compiler allows standard DOS wild cards in the input file names, and processes all source files that match the specification. No link step is required.

The pseudocode is executed by the main Foxbase+ program, which is a full interactive dBASE III work-alike. Its user interface is uncannily similar to that of dBASE, and, as is the case in dBASE, that interface can be tailored by means of a CONFIG.FX file that performs the same function at start-up as the CONFIG.DB file does for dBASE. In fact, both products can be configured by the same file, because if Foxbase+ cannot find a CONFIG.FX file, it will instead use a CONFIG.DB file, if one exists.

Actually, interactive Foxbase+ can run either precompiled .FOX files or .PRG source files. When Foxbase+ needs to load a program or procedure file, it first searches for a .FOX file; if one is not found, it loads the .PRG file and compiles it on the fly. In either case, the execution time is the same because the program is executed as pseudocode. So why precompile? Because the load time is greater for .PRG than for .FOX files, and the difference is especially noticeable for large programs loaded from within other programs.

As further evidence of its close compatibility with dBASE III, Foxbase+ provides a functionally identical full-screen editor, and through the CONFIG file, the user also can specify an alternate editor to be invoked by MODIFY COMMAND. When a source file is changed with MODIFY COMMAND, the .FOX file, if any, is deleted, so that the next execution forces reloading and recompilation of the newly updated program. It would be better if the pseudocode from the newly compiled version were saved out to disk, but only the stand-alone compiler can write .FOX files. However, during development it is entirely feasible to work directly with source files, or a mix of source and pseudocode, thereby making it unnecessary to run the compiler after every change to a source file.

As with dBASE, Foxbase+ provides an optional runtime system that runs only precompiled pseudocode files, without providing any of the interactive facilities. The price of the runtime system ($500) includes a license for unlimited distribution of Foxbase+ applications. Thus, the total cost of a development and runtime system comes to about $900, which is less than the price of a functionally equivalent package consisting of dBASE III, plus one of the other compilers. However, for users who already own dBASE III, the $900 must be compared to the price of an alternative compiler alone.

The Foxbase+ documentation consists of a single, standard-sized binder containing some 330 pages. This manual covers not only the installation, configuration, and operation of the system, but also provides a complete, if somewhat terse, reference to the Foxbase+ language. Although it is nearly as complete as the comprehensive dBASE III documentation, it is not meant as a tutorial in either database systems or in the dBASE III language. The Foxbase documentation, rather, is in the tradition of most compiler documentation that assumes some knowledge on the user's part of the underlying language; as such it is quite good.

Clipper is the most traditional of the three dBASE products, operating in the familiar two-step process of a classic language compiler.

Nantucket Corporation. Clipper is the most traditional of the three products, operating in the two-step process of a classic compiler: compilation to standard object code, then linking to a produce a stand-alone .EXE file. And, as is the case with most such compilers, the license agreement allows unlimited distribution of compiled applications. Further, Nantucket has removed copy protection from the latest version of Clipper. The product is installed by copying all the files to working disks or directories, and a batch file is provided to automate this process. Instructions also are provided for installing and running Clipper on a diskette-drive-based system, although such operation is more than a little inconvenient.

The compiler accepts the name of a single source file on the command line, like dBASE. All source files that are mentioned in DO and SET statements within the root file, and the files mentioned in those, are automatically processed. Clipper is intelligent enough to differentiate between names of stand-alone files and of procedures, and will look for stand-alone .PRG files only for those procedure names that did not occur in procedure files. Each execution of the compiler creates one object file that contains the output of all the source files processed.

An alternate method of specifying the names of files to be compiled is by means of a control file containing a list of file names. In that case, the automatic compilation feature is disabled, and only the named files are processed. This may be used to specify files that have names generated by macro substitution (for example, SET PROCEDURE TO &SOMEFILE), or to split an application's object code into two or more files for sharing with other programs.

Clipper comes with a customized version of the Phoenix PLINK86 linker, but the standard DOS linker also can be used. The Phoenix product allows the building of overlays to accommodate large applications on systems with limited memory, but at the expense of significantly longer link times. Both the compiler and linker support full path names, and the compiler returns DOS error-level codes on compilation errors, allowing the efficient automation of the compile/link process with batch files. Several sample batch files are provided.

Clipper's documentation is the weak link in an otherwise fine product. The main manual is the familiar three-ring binder in a slipcase; its size matches the original dBASE III (pre-Plus) manual. But the current version, dated Autumn 1986, comes with a manual for the Winter 1985 version and a substantial supplement booklet in a totally different format—spiral-bound with pages that are a different size and shape. The supplement contains information on enhancements added to the Winter 1985 version, but it mixes together features that are new dBASE enhancements with those that are extensions of previous extensions to dBASE. This may be workable to users already familiar with Clip-

per, but it is confusing for those new to this compiler, and unusable for those completely unfamiliar with dBASE. Nantucket does, however, plan to revise and integrate Clipper's documentation.

Using the two manuals (the base documentation with the supplement) would be bad enough, but even they are not complete. Additional information on still more changes and enhancements is provided in a READ.ME file and five .DOC files. What is more, this entire body of documentation must be used in addition to, not in place of, Ashton-Tate's voluminous dBASE manuals, because all of it covers only the differences from the base language definition—and no indexes are provided in either of the two main books.

WordTech Systems. Quicksilver is an update of WordTech's dB III compiler (which is no longer available). The previous product was a semicompiler that produced pseudocode for a runtime interpreter, but Quicksilver can produce native code. Otherwise, the two are quite similar in character, and Quicksilver can be considered a natural evolution from the last version of dB III. Through most of the development cycle, Quicksilver works just like dB III, because it produces pseudocode (called d-code) as an intermediate step. Testing and debugging is performed at this stage, with the conversion to native code performed only when the program is ready to go into production.

The package includes a demonstration version of the compiler that is limited to processing databases of no more than 16 records. Thus, a user may try out most functions before breaking the seal on the package containing the full version. If the product is found to be unsatisfactory, it may be returned for a refund as long as the operational copy remains sealed. This seems a reasonable approach, but it has one disadvantage. Although the demonstration version can compile any program the full version can, it cannot produce native code, and evaluating the compiler only at the d-code stage does not give a true picture of its performance.

Neither version of the compiler is copy protected, and installation involves simply copying the many files into working directories of a hard disk. (Although a hard disk is not mentioned as a requirement, operating Quicksilver on a diskette-drive-based system is not practical.) Also, the installation process is not documented very well: although the various files making up the compiler package are described in a READ.ME file, no information is included as to which are required, which are optional, and which must be in which directories. An installation program or batch file to perform the copy would be most useful. The supplied INSTALL program does not perform this function; it merely modifies the link library to reflect the hardware characteristics of the system. This phase of the installation is also inadequately described.

The creation of a stand-alone .EXE file from .PRG source code requires four steps: compilation to d-code, linking of the d-code modules, conversion of d-code to standard .OBJ files, and finally, linking with a standard DOS linker. This process is not as onerous as it seems, because testing and debugging are performed at the d-code stage, so only the first two steps are repeated during development. The final two

Quicksilver's automatic compilation is a useful feature, but it cannot differentiate between procedures and stand-alone files.

steps are typically performed only prior to distribution, although they might be required more often if the purpose of the testing is to optimize the execution time of the native code.

The compilation step can process a series of source files in sequence; the list may be specified in the command line or in a separate control file. In addition to the files explicitly named by either of these methods, the compiler may be instructed to automatically process all files mentioned in DO <file>, SET PROCEDURE, and SET FORMAT statements in any of the named files. In many cases it is possible to compile all of the modules of an application merely by naming the root file; the most common reason for naming more files is when file names are generated by macro substitution, as in SET PROCEDURE TO &SOMEFILE. A separate d-code file is created from each source file.

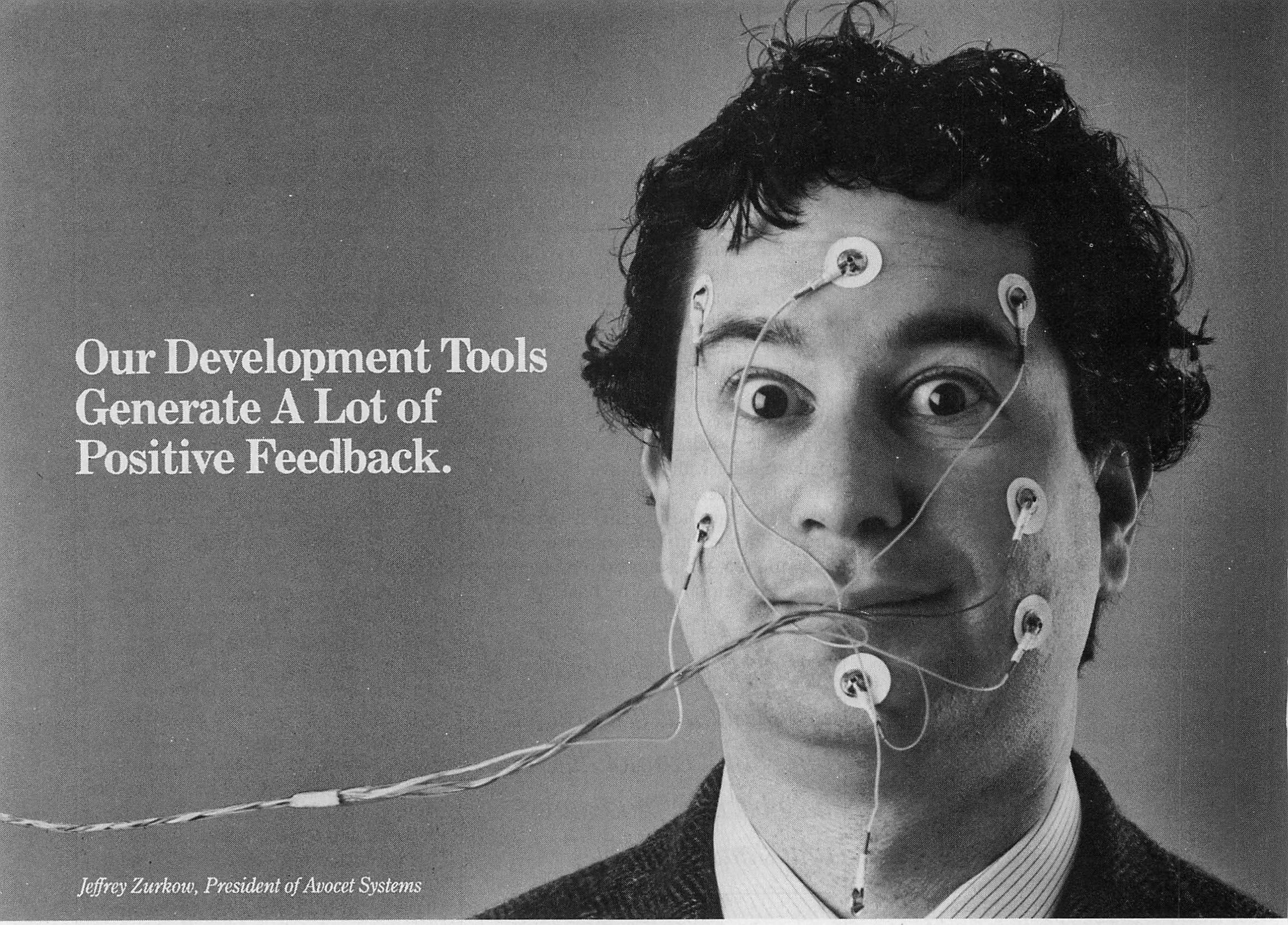
This automatic compilation is a useful feature, but its implementation has limitations. Unlike Clipper, Quicksilver cannot differentiate between names of procedures and stand-alone files. Given the statement DO ABC, it always will look for the file ABC.PRG and issue a warning message if such a file cannot be found. An option is provided to turn off such warnings, but then no notification is given of a bona fide missing file error. On the other hand, if ABC exists both as a separate file and as a procedure in another file, both copies get converted to d-code and are subsequently linked into the executable file, and the path of execution may well go to the wrong one.

In operation, the compiler exhibits several anomalies. The first is lack of support for paths in source file names, both those explicitly named on the command line and those that are mentioned in DO and SET statements in the source file. This is documented in the READ.ME file as an "execution discrepancy." Presumably this problem will be fixed in a subsequent release.

The second problem is more serious because it is a direct result of the compiler's design; that is, WordTech Systems considers it a feature. D-code files produced by the compiler are identified by prefixing the source file name with an @ sign. For example, the source file ABC.PRG creates an output file named @ABC.PRG. If the source file name is already eight characters long, the last character is dropped. Alternately, a command-line switch can be set to instruct the compiler to overlay the first character instead. The DOS file-naming conventions are already restrictive enough, but this scheme effectively limits file names to seven characters—moreover, it is unnecessary because DOS provides a three-character extension just for the purpose of differentiating file types. With approximately 40 legal file-name characters, some 64,000 different three-character extensions are available. It seems that WordTech could have chosen one of those and left the user's file names alone.

The third problem is a result of the design of Phoenix's PLINK86 linker, which was used to construct the compiler .EXE file. If the compiler has been invoked with a specific path, such as \DBASE\QS\DB3C, and if that path is not part of the DOS search sequence that is specified by the user in the PATH command, then the compiler's overlays cannot be found.

Once all of an application's source files are compiled, the second step gathers together all of the d-code files. As with the compiler, the d-code linker automatically processes all files mentioned in DO and SET statements in that file and all subsequent files; however, unlike the compiler step, this feature cannot be turned off. In addition, an explicit list of files may be specified on



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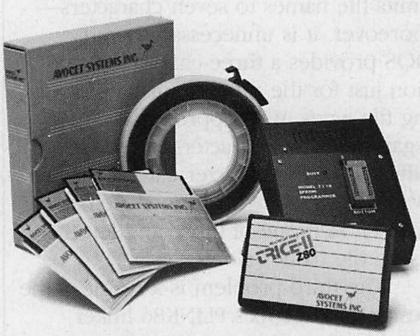
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the command line or in a control file. As a consequence of the unfortunate naming convention at the d-code stage, the linker must be told if compiler output files are named by replacement of the first character instead of the last.

The d-code linker operates in two modes, depending upon whether the output is intended for execution as d-code or for conversion into a native code .EXE file. In the first case, three output files are produced. For an application with a root program named ABC.PRG, the output files would be ABC.EXE, ABC.OVL, and ABC.DBC. The size of the .EXE file is always 133KB, regardless of the size or nature of the application program; it is, in fact, the runtime system that interprets the application-specific d-code contained in the other two files. Each application therefore replicates the common runtime code, unnecessarily taking up processing time to create it and disk space to store it. It would be much more efficient to provide a single copy of the runtime system.

In the linker's other mode, only the .DBC file is created. It cannot be executed, but must be processed with the optimizer program into .OBJ format, then linked with a DOS linker. For a root source file, the optimizer creates five .OBJ files and a linker control file that provides the names of these object files, the name of the output .EXE file, and the names of link libraries. The optimizer automatically calls the DOS linker; a command-line parameter controls whether this is the standard LINK.EXE of DOS or Phoenix's PLINK86. However, neither one of these linkers is provided with the Quicksilver package.

With its four steps, Quicksilver is more complex in operation than the other two products. The process may be automated with batch files, but this is more tedious than it needs to be because of the incomplete path support and the fact that the various programs do not return DOS error-level codes. A compiler design such as this one makes sense only if stopping at the intermediate code stage saves a significant amount of time over the creation of native code .EXE files; however Quicksilver spends too much time doing unnecessary things at this stage. Although the concept is good, the implementation has a some major design flaws.

Quicksilver's documentation, however, is more than adequate. It consists of a single binder, in standard format with a slipcase, containing some 360 pages. All of the information is specific to Quicksilver, with no duplication of dBASE III documentation. Language features are described only to the extent that they differ from the dBASE standard. The operation of the compiler and considerations of program efficiency are covered very thoroughly. The major failing, as mentioned, is the sketchy description of the installation process. The manual does include a useful glossary and a good index.

dBASE III COMPATIBILITY

Regarding file compatibility, all database, label, and report files are interchangeable among dBASE III and the three compilers, but index files are a different matter. Clipper and Foxbase+ implement a different, incompatible index structure. They cannot use index files that have been created by dBASE, and dBASE cannot use theirs.

Within Foxbase+, the conversion from dBASE to Foxbase+ index format is performed automatically as required. Whenever an existing index file is accessed, Foxbase+ tests whether it is in its own format or that of dBASE; if it is the latter, a new index file is generated and saved on the fly, using the key expression obtained from the dBASE index file. Clipper provides a simple program for creating indexes, but the user must provide the key expression.

All database, label, and report files are interchangeable among dBASE III and these compilers, but index files are another matter.

These nonstandard indexes are identified by different extensions (.IDX in Foxbase+, .NTX in Clipper), so that both they and dBASE index files may coexist. However, updating files alternately with a compiler and dBASE eventually will render one set of indexes out of date. This is less likely with Foxbase+, which is so much like dBASE III that it is really unnecessary to use both products on the same set of data. However, it is quite likely that dBASE would be used for interactive testing of Clipper-developed programs.

The differences in index formats are supposedly for purposes of efficiency. But is the gain in performance really worth the problems of incompatibility and of maintaining two sets of indexes? As shown by Quicksilver and other products such as Fox & Geller's Quickindex, an index structure compatible with that of dBASE can produce results that are just as good. Quicksilver indexes, although not identical with those created by dBASE, are fully compatible, and provide performance that is better than that of Clipper and about equal to that of Foxbase+.

Each of these compilers supports a slightly different version of the language. Each is both a subset, because it does not implement all of the dBASE features, and a superset, because it adds some features; yet all three differ in the features they do not support and the features they add. Tables 2 and 3 summarize respectively the major deletions from and additions to the dBASE language by the three products.

Because the dBASE language is defined only in actual commercial releases of the product, it is inevitable that some lag will occur between a new Ashton-Tate release and the implementation of its features in the after-market. However, in the case of Clipper and Quicksilver, most of the missing features are not the result of playing catch-up, but of conscious design decisions.

It is certainly reasonable to assume that commands such as ASSIST, HELP, and MODIFY COMMAND, and SET options such as STEP, ECHO, DEBUG, and DOHISTORY, are used only from the dot prompt and are not needed under program control. (Even Ashton-Tate's dBRUN, the runtime system for executing encrypted .PRG files, omits support for these features.) It is also understandable that commands for interactive creation of databases, screens, reports, and mailing labels are not supported by the two compilers. In most cases, these are created once when an application is first installed, and it is not necessary to change them from within a program. Both Clipper and Quicksilver provide stand-alone file creation utilities (these are described later in the article). And, with the exception of index files as mentioned above, files for any of the compilers may be created by dBASE.

But the dBASE III language also provides a capability of creating data files under program control, not only from interactive input. This is accomplished via the CREATE command with the FROM option. The file that is named in the FROM clause is a structure file typically created by the command COPY STRUCTURE EXTENDED; it is a data file describing the fields of another data file. The structure file may be modified under program control, then used to

create a new data file. All three products implement the COPY STRUCTURE EXTENDED and CREATE FROM commands. In addition, Clipper accepts the plain CREATE command, but executes it differently than dBASE. Instead of asking the user for input to define the new file's structure, Clipper creates an empty structure file; then, records defining the structure may be written into the file under program control. It therefore would be possible, if not very useful, to duplicate through programming the interactive CREATE and MODIFY STRUCTURE commands of dBASE III Plus.

Both Nantucket and WordTech chose not to implement the interactive data input commands such as APPEND, BROWSE, CHANGE, EDIT, and INSERT. The Quicksilver documentation makes a persuasive point that such commands are a hazard to data integrity because they allow the input of unvalidated data directly into data files. WordTech argues that the proper way to enter data is to write a program to accept user input into memory variables, validate it, and only then apply it to the database.

Methods are available for ensuring data integrity even with automatic input procedures, and many traditional applications are programmed in such a way. This was amply demonstrated when an attempt was made to test these compilers on several large production applications: most of them used some form of input that is not supported by either Clipper and Quicksilver.

Foxbase+, on the other hand, attempts to duplicate most of the features of dBASE, including the interactive ones. Its list of missing and added features is the shortest, thus it is the closest in capabilities to dBASE. Although the most useful data entry commands are implemented, some of the newer conveniences, such as CATALOG, VIEW, and QUERY files, are missing. Because they are most useful in an interactive data query mode, it is not surprising that they are missing from Clipper and Quicksilver, but their absence from Foxbase+ makes that product less than an exact replacement for dBASE III Plus.

The enhancements offered by each of these products are mixed blessings. Some of them, such as memory arrays and multiple relations, address serious limitations of dBASE III and are indeed useful, but they come at a price. One of the major advantages of using dBASE III is that it is so widely accepted; like the IBM PC itself, it has come to be the de facto standard, shortcomings and all. Deviating from that standard should not be done lightly. Incorporating the en-

TABLE 2: *Compiler Language Deficiencies*

	FOX	NANTUCKET	WORDTECH
Product	Foxbase+	Clipper	Quicksilver
APPEND	●	○[a]	○[a]
ASSIST	○	○	○
BROWSE	●	○	○
CATALOG files	○	○	○
CHANGE	●	○	○
CREATE (database)	●	●[bc]	○[cd]
CREATE/MODIFY[e]	●	○	○
DISPLAY/LIST MEMORY	●	○	●
DISPLAY/LIST STATUS	●	○	○
DISPLAY/LIST STRUCTURE	●	○	●
EDIT	●	○	○
ERROR ( )	●	○	●
HELP	●	○	○
INSERT	●	○	○
LOAD	●	○	●
MESSAGE ( )	●	○	●
QUERY files	○	○	○
RETURN TO MASTER	●	○	●
SET (Menu-driven)	●	○	○
SET convers. items[f]	●	○	○
SET ORDER	●	●	○
VIEW files	○	○	○
Foreign file formats[g]	○	○	○

This list of dBASE III features is not complete—each of these commands is included here only to point out that it is not supported by one or more of these compilers.
● = *Implemented* ○ = *Not implemented*
[a] *APPEND FROM <file> and APPEND BLANK are implemented.*
[b] *Creates an empty Structure Extended file.*
[c] *CREATE <file> FROM <strucfile> is implemented.*
[d] *A stand-alone utility for creating databases is provided.*
[e] *CREATE/MODIFY COMMAND, LABEL, REPORT; MODIFY STRUCTURE.*
[f] *SET TALK, HELP, DEBUG, STEP, SAFETY, MENU, etc.*
[g] *SDF format is supported in COPY and APPEND, but not DIF, WKS, SLK, and PFS formats.*

Clipper and Quicksilver address only the preprogrammed mode of dBASE III Plus, while Foxbase+ supports most of its interactive processing features as well.

TABLE 3: *Major Language Enhancements*

	FOX	NANTUCKET	WORDTECH
Product	Foxbase+	Clipper	Quicksilver
Memory arrays	●	●	○
Multiple relations	●	●	○
Edit memo during browse	●	○	○
Memo manipulation routines	○	●	○
User-defined functions	○	●	●
C and ASM subroutines	○	●	●
Programmable end-user help	○	●	○
Execute interrupts	○	○	●
Command-line parameters	○	●	●
Menu structures	○	●	○
Windowing	○	○	●
Port I/O	○	○	●
Max. number of open files	48	15	80+

● = *Yes* ○ = *No*

Foxbase+, in keeping with its attempts to duplicate the implementation of dBASE III Plus, also provides the fewest enhancements to the language facilities.

hancements of one compiler into a program means that program cannot be executed under another compiler; more significantly, such a program cannot be tested interactively with dBASE.

The most welcome extensions—arrays and multiple relations—are provided by Clipper and Foxbase+. In Clipper, arrays are always private (local to the procedure in which they are declared) and limited to one dimension; Foxbase+ arrays may be either one or two dimensional and either public or private. Clipper allows as many as eight relations out of one data area; Foxbase+ sets no limit.

Clipper and Quicksilver both provide for user-defined functions (UDFs), which are value-returning subprograms similar to the built-in functions of dBASE III. It is possible to effectively expand the syntax of the language by adding what become key words. Although the same effect can be achieved with procedures that return values in global variables, UDFs create more readable code because it is immediately obvious that a value is being returned. Otherwise, the same variable scoping rules apply to UDFs as to other subprograms in dBASE III: variables known at the level of the calling procedure are available to the function; parameters and variables declared within the function are local.

UDFs may be written in C or assembly language, as well as in dBASE. This is an easier interface than the one provided by the LOAD and CALL statements of dBASE (also implemented in all three compilers) because the functions greatly simplify the returning of values from the foreign language to the dBASE calling procedure. Clipper and Quicksilver are both true compilers that produce linkable object code, thus at link time the incorporation of foreign language code is no more difficult than linking in separately compiled modules. Libraries of UDFs for Clipper are available, such as Tom Rettig's Library, Clipper Edition, (see Product Watch, Dave Browning, this issue, p. 179).

Foxbase+ and Quicksilver circumvent the operating system's limitation of 15 files open at once. DOS allows at most 20 file handles, then uses 5 of them for standard input, standard output, standard error, printer, and serial port, leaving 15 for use by the program. With clever programming, it is possible to create the effect of more files open at once by closing files whenever a new one needs to be opened and no more handles are available. The position in the file just closed is saved, so that it may be repositioned when reopened (perhaps causing the closing of another file) for the next I/O request. Files that have been accessed in this mode are said to be virtually open. The allocation of a small number of physical handles to a larger number of files is analogous to the process of virtual memory management, in which a small amount of physical memory simulates a larger amount of logical memory.

Foxbase+ uses this approach to expand the total number of open files to 48. Within this number, the program is allowed as many as 10 database files (the same as dBASE III) and no more than 21 index files. A smaller limit may be set in the CONFIG.FX file.

For Quicksilver, the upper limit on concurrently open files is not specified, but WordTech guarantees that 10 database files, each with as many as 7 index files, may be logically opened at one time. The runtime file system manages these files among 3 to 10 physical file handles; the number is set by modifying a link-time library with the installation program. The remaining handles (from the total of 15) are available for other types of files, such as format, alternate, report, and label. Note that file handles are never needed for procedure files, because procedures are incorporated into the load module at link time.

> *The most welcome extensions to the dBASE III language—arrays and multiple relations—are provided by Clipper and Foxbase+.*

Of course, this capability also comes at a price. Virtual file processing takes more time because if a file is closed and later reopened, additional processing and disk accesses are required to close and open the file, and its data must always be read in from disk. When a file remains open, the data can remain in the system buffer, and, most likely, the next I/O request can transfer data without performing a time-consuming physical disk read.

When concurrent processing of a large number of files is mandatory, using a virtual file manager is certainly easier than programming the equivalent logic in standard dBASE III. But an immutable rule of system development states that if the program ever needs to be returned to the standard, the effort required to remove an enhancement is proportional to the fourth power of the effort saved by the enhancement.

Clipper and Quicksilver provide a means of switching the enhancements on and off. In the former, if a public variable named CLIPPER is defined, the compiler initializes it to the value .TRUE. To dBASE, this name has no special meaning, and it is initialized, as are all public variables, to a .FALSE value. Therefore, a program may incorporate the following logic:

```
IF CLIPPER
   Clipper enhancement statements
ELSE
   Normal dBASE statements
ENDIF
```

Quicksilver, on the other hand, compiles lines beginning with the special sequence *\, which dBASE considers as a comment (because it begins with a *). A compile-time switch may be set to ignore this feature, in case the source contains real comments beginning with these two characters.

The ability to turn off enhancements, of course, addresses only the problem of syntax errors that dBASE generates when it encounters unimplemented constructions in the source code. What this leaves unresolved is how to perform the equivalent functions in standard dBASE code. In most cases, it is not possible to emulate the enhancements, so that programs using a specific compiler's features effectively become a language foreign to dBASE.

Some of the more comprehensive enhancements are indeed hard to resist. Clipper implements two very useful features. The first is a menu system that automates point-and-shoot selections in several commands analogous to SAY, GET, and READ. Menus may be organized either horizontally or vertically, and a brief explanation may be specified for each entry. A highlight bar is moved through the selection with the cursor keys or by pressing the first letter of the menu text, and as each entry is highlighted, the explanation appears, 1-2-3 style, on a message line. A menu selection is made by pressing the return key, PgUp or PgDn, whereupon the relative number of the selected entry is returned in a menu variable.

Clipper's other major enhancement to dBASE is customized help. Pressing F1 during full-screen entry invokes a procedure called HELP.PRG (provided one had been linked into the load module, otherwise the keystroke will be ignored). As parameters, it receives the

name of the calling program, the line within it where help was invoked, and the name of the variable that was waiting for input when F1 was pressed. Using this information, the program can display context-sensitive help messages. To facilitate this helpful aid, Clipper also provides commands to save and restore the screen display.

Quicksilver's major extension is a windowing system implemented by a series of commands that parallel the operations with databases. Windows are created, opened, written to, and closed; saving and restoring the screen underlying a newly opened window is performed automatically with no effort on the part of the programmer.

Quicksilver also adds support for the low-level functions of DOS and BIOS interrupts and port I/O. The latter is useful mostly for implementing sounds on the speaker, because most other I/O activities are supported by the high-level features of the language. On the other hand, the ability to invoke DOS and BIOS interrupts directly is quite useful, permitting access to a number of system services that would not otherwise be available.

Besides the features that are listed in tables 2 and 3, many other differences of a more minor nature are present among the compilers. Some are additional features implemented as extra functions or as new options in existing commands, others are minor, but annoying, deviations from the dBASE implementation. For example, Quicksilver requires that the fields present in a SORT statement be separated by plus signs instead of commas. The documentation makes light of this seemingly minor difference, but it misses one very significant point: a list delimited by plusses is one expression, and all the elements must be of the same type. On the other hand, the standard syntax allows sorting on a compound key made up of more than one type of variable. It is possible to insert functions to convert variables from one type to another, but this requires more changes than merely replacing commas with plus signs.

In general, Quicksilver contains more of these annoyances than the others. It requires that the ON phrase specifying the sort key precede the TO phrase specifying the output file; standard dBASE syntax allows either order. A PROCEDURE statement is accepted only if the first noncomment statement in the file is PROCEDURE, meaning that Quicksilver makes a distinction between procedure files and program files that can be called directly. This prevents the very useful construction, acceptable to dBASE, Clipper, and Foxbase+, of setting a procedure file from within itself:

```
* Within file ABC
SET PROCEDURE TO ABC
DO MAIN
PROCEDURE MAIN
...
...
PROCEDURE ... etc.
```

Also, in Quicksilver, UDFs must reside in a separate file, while in Clipper they can be included in the main procedure or in any procedure file.

Clipper has fewer of these implementation differences. The key word REST is not supported as a scope, but the equivalent WHILE .T. is suggested as a replacement. More significant is the fact that many standard dBASE functions are not included in the link library, but are supplied in several object files. The user must remember to specifically name them at link time, whereupon all are linked in without regard to how many are actually called. They also are provided in source code (dBASE, C, and assembly language), so the user may compile them and add them to the main Clipper library, or an auxiliary library can be created.

Users of traditional programming languages will require some adjustment to work with the error reporting of a dBASE compiler.

ERROR HANDLING

Users of traditional programming languages will require some adjustment to work with the error reporting of a dBASE compiler. Many seemingly simple errors are not caught at compilation, only at runtime. For example, mixing field names of different types in an expression is not noticed by the compiler because the database structure that defines the field types is not known until runtime. Similarly, referencing an undefined variable is not flagged because the compiler does not know if it is the name of a field in a data file or a public variable that has been defined in a previously executed procedure.

Given these limitations, all three compilers do a creditable job of discovering and reporting source code errors. In each case, the line in error and an error message are displayed on the standard output device. This output may be redirected to a printer or disk file. Using the latter approach, a programmable editor may be set up to highlight each error in the source code file.

Quicksilver generates a line count to show the progress of compilation. On screen, this displays odometer fashion on one line, but when redirected, each line number generates a separate line on the printer or in the output file. A compile-time switch is available to turn this feature off. Another inconvenience is that after each error, Quicksilver stops and requires a key press to either continue or abort. This too can be disabled, but it would be more logical to make continuous operation the default mode. If, indeed, output is redirected but continuous mode is not enabled, an error will appear to hang the system while the compiler waits for a keystroke for which no prompt actually appears on the screen.

Clipper also shows the compilation line count, but sends it to the screen regardless of output redirection. Error messages go to standard output. An option is available to suppress the creation of an object file, permitting quicker compiler passes for syntax checking only. Like Quicksilver, Foxbase+ sends everything to standard output, but it displays no progress messages and needs no user intervention.

For the most part, all three compilers were reliable both in operation and in generating robust code. Quicksilver had the most exceptions, as a result of its extremely conscientious error reporting in the documentation. Most of the bugs it reports are minor, and once known, easy work-arounds can be devised. However, one problem was somewhat misrepresented in the documentation. The SET ORDER command is documented (in the bug-reporting section of the READ.ME file) as not implemented, but it really should be tagged as not working. The command is compiled without complaint, but when executed it has no effect.

The Foxbase+ compiler seemed robust, although several minor problems were evident in the interface between the interactive Foxbase system and DOS. The RUN command uses the PATH, not COMSPEC, to locate the COMMAND.COM file; the command fails if the root directory containing COMMAND.COM is not in the path. If, as is common, the root contains no executable files besides the command

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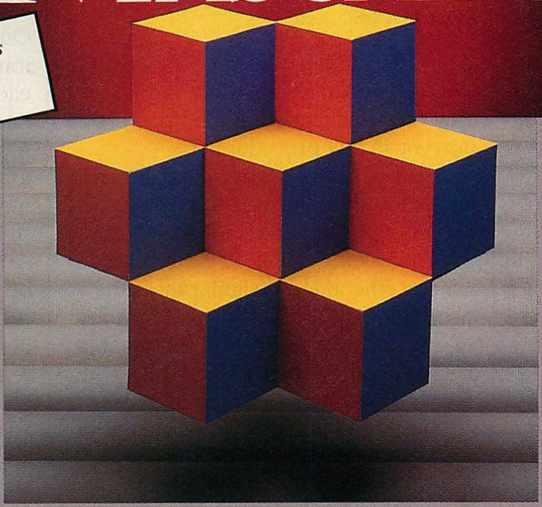

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processor, then the root directory does not really need to be in the path—every additional directory that DOS must search adds to the system's overall response time.

If the temporary exit to DOS is successful, the return to Foxbase+ is not quite clean: the last line of the DOS output is erased by the dot prompt. For example, if the user were running CHKDSK, the last line that gives the amount of free memory (often the very reason for running CHKDSK in the first place) gets overwritten.

Another problem is that Foxbase+ somehow manages to disrupt the DOS environment that is passed to the secondary copy of the command processor. Evidently the environment is not terminated properly, as shown by running the DOS SET command: it displays a garbage string at the end of the valid environment strings. Although no obvious problems were traced to this anomaly, such lack of attention to details undermines the user's confidence in the product. However, these problems are minor in comparison with the generally reliable operation of all three compilers in the majority of the tasks with which they were tested.

DEBUGGING DECISIONS

One of the major advantages of an interpreter is that it allows interactive execution for debugging purposes. Foxbase+ provides the same debugging facilities as dBASE: SET STEP executes programs a single statement at a time, SET ECHO displays each statement as it is executed, and SET DEBUG sends the echo output to the printer instead of the screen. In addition, the SUSPEND command allows temporary exit from a program to the dot prompt, while RESUME restarts the procedure. And, as in dBASE, an error while executing a procedure produces the same choice of CANCEL, IGNORE, or SUSPEND. The one facility not provided by either dBASE or Foxbase+ is the setting of breakpoints in the program, but given the interpreter's quick turnaround between editing and executing, it is quite practical to insert SUSPEND statements at strategic points in the source code.

The debugging facilities of a compiler, to a large extent, are an attempt to replicate the interactive mode of an interpreter. It might appear that a dBASE compiler would not need a debugger, because the Ashton-Tate interpreter is available for that purpose. But it may not always be possible to use interactive dBASE to debug Clipper or Quicksilver programs. First, the programs may make use of language extensions, and second, whether inadvertently or by design, the compiler may execute certain statements in a subtly different way. Therefore, using a compiler's own debugger is often the only way to find the persistently elusive bugs.

The Quicksilver debugger is more sophisticated and provides more of the capabilities of an interactive interpreter than that of Clipper. To debug a Quicksilver program, it must be compiled and the d-code linked with a special debugging option enabled. The link step is very quick, because no library routines are placed in the output, and no executable file is created. Instead, the d-code must be loaded and executed by the debugger program. (It is not clear why WordTech wouldn't implement a similar process with a nondebugging runtime in order to accelerate the normal link step that is performed so often during development.)

Quicksilver's basic mode of operation mimics dBASE with STEP and ECHO set on: each press of the Return key displays the next source statement and executes it. A comprehensive set of commands provides full control over program execution, output redirection, display and modification of memory variables, and manipulation of data files. A particularly useful feature allows backing out all changes made with the debugger to data files, returning them to the state they were in when the debugger gained control. For example, a user may switch through several data areas, move the record pointer around in each, then with one command restore all pointers and reselect the work area where he started.

Foxbase+ provides the same debugging facilities as dBASE, including SET STEP, SET ECHO, SET DEBUG, SUSPEND, and RESUME.

Although this debugger does not implement all of the features of the dBASE interpreter, the control it allows over a program's environment is fairly complete. Two major exceptions are the inability to change data in files, and to interactively open data, index, or format files from within the debugger. Fixing a forgotten USE or SET statement would save many a trip through the editor, compiler, and linker. On the other hand, the ability to set up as many as 12 breakpoints by line number or condition, and to display source code without invoking an editor, are conveniences not offered by dBASE. The Quicksilver debugger's greatest fault is the command structure: because commands are single characters, the set of 30 commands includes some very arbitrary choices. For example, K moves the record pointer in a data file, Z executes a script of debugging commands from a disk file,] clears the screen, and [ejects a page on the printer. This is somewhat mitigated by the ability to display a help screen of command codes, summoned by the easily remembered H command. On the whole, Quicksilver's debugger is a well-designed development tool.

Clipper's debugger is incorporated into programs by linking in an extra object module; no changes are required at the compilation step. This debugger is much more primitive than Quicksilver's, and is more reminiscent of DOS DEBUG than of dBASE. It cannot display source code, but refers to the source program by line numbers. This is analogous to DEBUG's references by address, and just as using DEBUG requires an address map, using the Clipper debugger requires a line-numbered listing. The compiler package includes a utility program that creates such listings.

The command set consists of only 14 commands. A maximum of nine breakpoints may be set by line number, but only one by condition. One useful feature (not available in the Quicksilver debugger) is the ability to execute DOS commands; this is often useful for renaming or copying files that are discovered to be missing in the middle of a debugging session. However, as a debugger for a database manager, this one is virtually crippled by its total lack of control over data files. Not only is it incapable of opening files and changing data in them, it cannot even display the contents of the files.

CREATING FILES

Clipper and Quicksilver each provide a stand-alone utility, invoked from the DOS prompt, that creates database files. Clipper's is the better of the two: it includes a full-screen user interface similar to the CREATE command of dBASE. Although it can modify the structure of an existing file, it is not equivalent to the MODIFY STRUCTURE command because it deletes all existing records.

Quicksilver's create utility has a scrolling teletype-style interface that

does not allow backing up to correct a previously entered field. It does not support the creation of memo or date fields, and cannot modify the structure of an existing file. Invoking it from within an existing file overwrites the file with no warning.

Clipper also provides programs that create label and report files. Again, the screen interface mimics that of the corresponding dBASE III commands, but in their pre-Plus versions. The name of the data file from which the labels or reports are created is not specified during the creation process; therefore no check is made on the validity of the field names. Quicksilver relies on dBASE III to create label and report files.

Because of the size of Quicksilver files, a large application may exceed the capacity of a diskette. To aid in distributing such an application, WordTech provides a SPLIT program that divides a file into subfiles of a specified size. The pieces may be recombined later with the DOS COPY command.

An opposite function is performed by the FOXBIND program from Fox Software. It combines a set of source files into one procedure file, preceding each module with a comment banner and a PROCEDURE statement. To be really useful, this program needs to be supplemented by others for more comprehensive source library maintenance, especially the replacement of a named module in the procedure file. As it is, input files are merely appended to the end of the output file without the compiler checking if procedures of the same name already exist within it.

TABLE 4: *Compilation Performance*

	FOX	NANTUCKET	WORDTECH	
PRODUCT	Foxbase+	Clipper	d-code	Native
EMPTY FILE				
Compile time	2	32	53	99
File size	40	125,740	192,188	119,312
DISP.PRG				
Compile time	3	35	57	100
File size	355	127,052	193,020	121,408
DBBENCH.PRG				
Compile time	3	38	60	123
File size	924	132,716	196,073	138,889
570-LINE PROGRAM				
Compile time	11	66	91	198
File size	9,933	139,516	222,338	182,866

Compile times in seconds.
File sizes in bytes.
The test system was a 6-MHz PC/AT with 640KB of RAM and a standard CMI 20MB hard disk. The times are the total for compilation and linking, where applicable, and include the time for loading compilers and linkers from disk. I/O files were also on disk; a RAM disk was not used.

Foxbase+ compiles the fastest since it produces intermediate code. Quicksilver takes longer to produce pseudocode than Clipper does to produce native code.

NETWORK SUPPORT

All three products support networking; that is, programs created by each will run on a network and will handle multiuser access to databases. Nantucket provides networking capabilities with every copy of Clipper, Quicksilver needs the addition of an optional program costing $99, and Foxbase+ has a separate higher-cost multiuser version.

Clipper and Quicksilver programs were successfully installed and executed on the IBM Token-Ring Network under the IBM Network Control Program, but this was more a demonstration than a test. The following information is provided on the basis of each product's specifications, but the packages should be considered against a configuration's requirements before purchase.

All three products support the dBASE III networking commands and functions: SET EXCLUSIVE, USE EXCLUSIVE, FLOCK(), and RLOCK(). Therefore, concurrency control can be programmed in the same fashion in all of them. But differences exist in the degree of automatic concurrency control provided in the absence of explicit file and record locks. In dBASE III and Foxbase+, a file is automatically locked for the duration of any of 16 commands that operate on multiple records, such as APPEND FROM, COPY, INDEX, JOIN, and so on. Clipper performs no such automatic locking, leaving concurrency control entirely up to the programmer. Quicksilver, in its standard manual mode of concurrency control, provides automatic file locking for seven such commands: COPY, COPY STRUCTURE, INDEX, SET ALTERNATE TO, JOIN, SORT, and TOTAL.

But Quicksilver also provides an alternate mode, specified by the SET AUTOLOCK command, that extends automatic concurrency control beyond that provided by dBASE III Plus. With SET AUTOLOCK ON, the Quicksilver LAN control program will automatically lock files on the occurrence of any of 18 commands, and in addition will automatically lock an individual record for the duration of a REPLACE command. Also, in the event that a lock attempt fails because the file or record is already locked, Quicksilver automatically retries the attempt. The language extensions include commands to set the delay between attempts and the number of attempts before an error is generated. In dBASE III and Foxbase+, failure of an automatic file lock immediately results in a runtime error.

The multiuser version of Foxbase+ supports most of the features of dBASE III Plus Network Administrator, with the exception of the file encryption and the LIST USERS command. Otherwise, the syntax of programs written for the Administrator are acceptable to Foxbase+. However, significant differences are apparent during execution.

In Foxbase+, only the command USE EXCLUSIVE can prevent multiple read access to a database file. File or record locks applied with the FLOCK and RLOCK functions, and locks applied automatically by certain commands (the same ones as in dBASE III) are in effect only for write access; they do not prevent multiple read access. Although it is often useful to differentiate between read and write locks, the disadvantage is that this behavior is very different from that of dBASE and the other compilers. A program ported from another system, even though it compiles with Foxbase+, may have totally different results when executed. Whereas the single-user version of Foxbase+ is the closest to dBASE III, in this respect the multiuser version is the farthest removed from the standard.

A PERFORMANCE CODE

The performance of a compiler has two aspects. One is how fast it produces executable code, the other is how fast the code it produces executes. The speed of compilation was tested here using five programs varying from zero to more than 500 lines of source code. Although many commercial applications

are larger than this, the dBASE language encourages modular programming, so that individual modules processed by a compiler should seldom exceed this size. The results of the compilation tests are provided in table 4.

The test system was a 6-MHz PC/AT with 640KB of RAM and a standard CMI 20MB hard disk. The times represent the total for compilation and linking, where applicable, and include the time for loading compilers and linkers from disk. I/O files were also on disk; a RAM disk was not used.

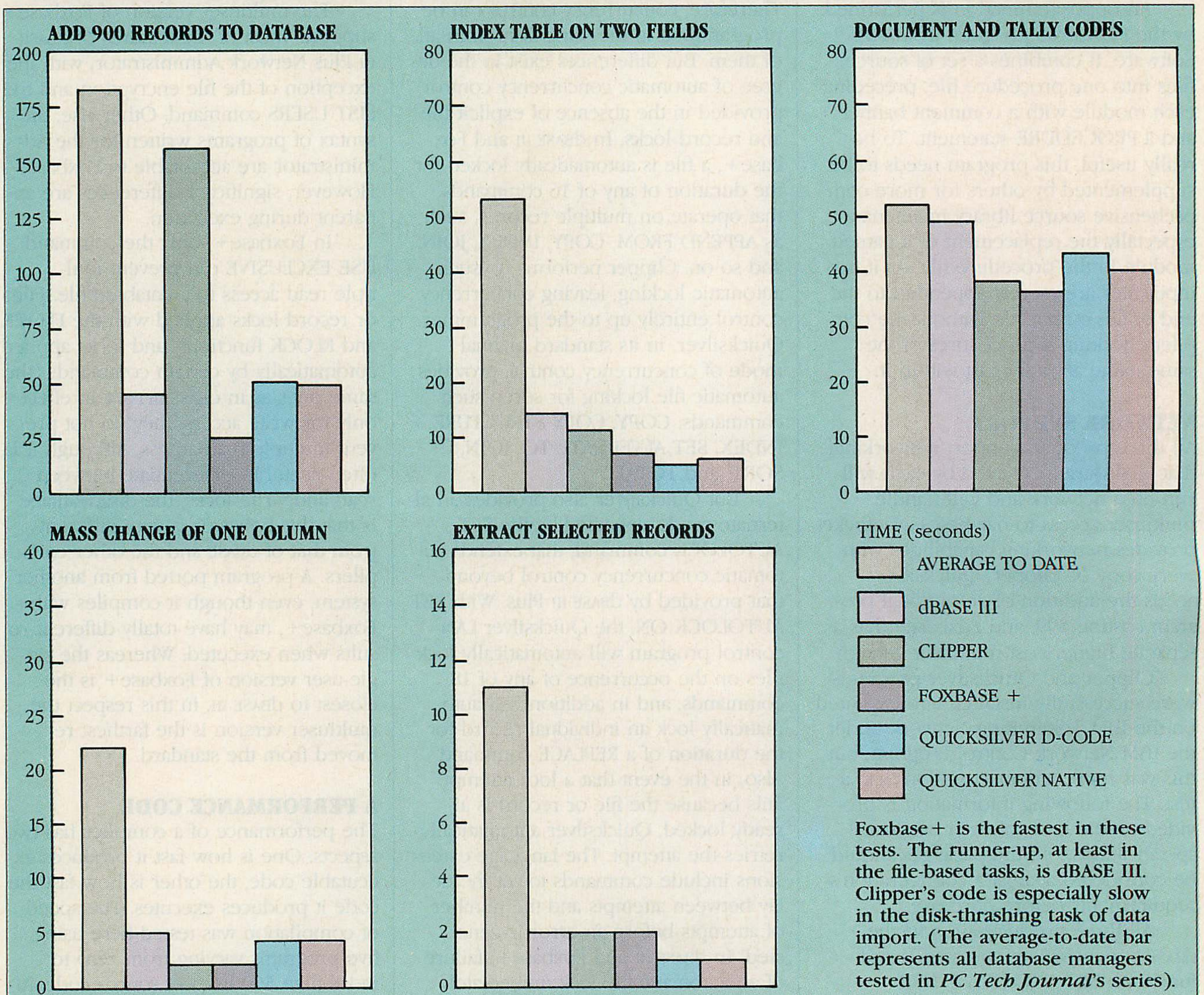
The empty file consisted of only an EOF mark, 1AH. The size of the resulting code indicates the size of the basic complement of library routines that make up the standard entry and exit modules placed in the output regardless of the source code. For Clipper and Quicksilver, essentially all of the time was spent in the link steps, where the base routines are copied from libraries to the output files. The compilation step itself, once the compiler was loaded from disk, took an insignificant amount of time to process the null file.

For Quicksilver, two results are tabulated. One is for the creation of d-code, the intermediate pseudocode created by compilation and the first link step. The program size for d-code is the total of the three files that are produced in this form; this includes a form of runtime system that interprets the d-code. This two-step process is the one most often used during development. The times shown for Quicksilver native code are totals for all four steps: compilation, d-code linking, conversion to object files, and final link to create the .EXE file. The second of these steps was limited to creating nonexecutable d-code expressly for the purpose of conversion to native code.

As shown in table 4, Foxbase+ far surpasses the other two in compilation speed. This is not surprising, since it requires no link step (the step in which the other two spend most of their time), and really does not process the source code very much, leaving it in an intermediate form for further processing by the runtime system. What is surprising is the poor showing of Quicksilver in producing pseudocode; it takes longer to do this than Clipper takes to compile and link to a native code .EXE file. Part of the reason could be that at each compilation, Quicksilver reinvents the wheel, as it were, by creating a new copy of the runtime system that will interpret the d-code. Clipper's times are quite respectable for a native code compiler, and most of this time is spent processing the large link library.

The linker used to produce the .EXE files for both Clipper and Quick-

FIGURE: *Standard Database Tasks*



Foxbase+ is the fastest in these tests. The runner-up, at least in the file-based tasks, is dBASE III. Clipper's code is especially slow in the disk-thrashing task of data import. (The average-to-date bar represents all database managers tested in *PC Tech Journal*'s series).

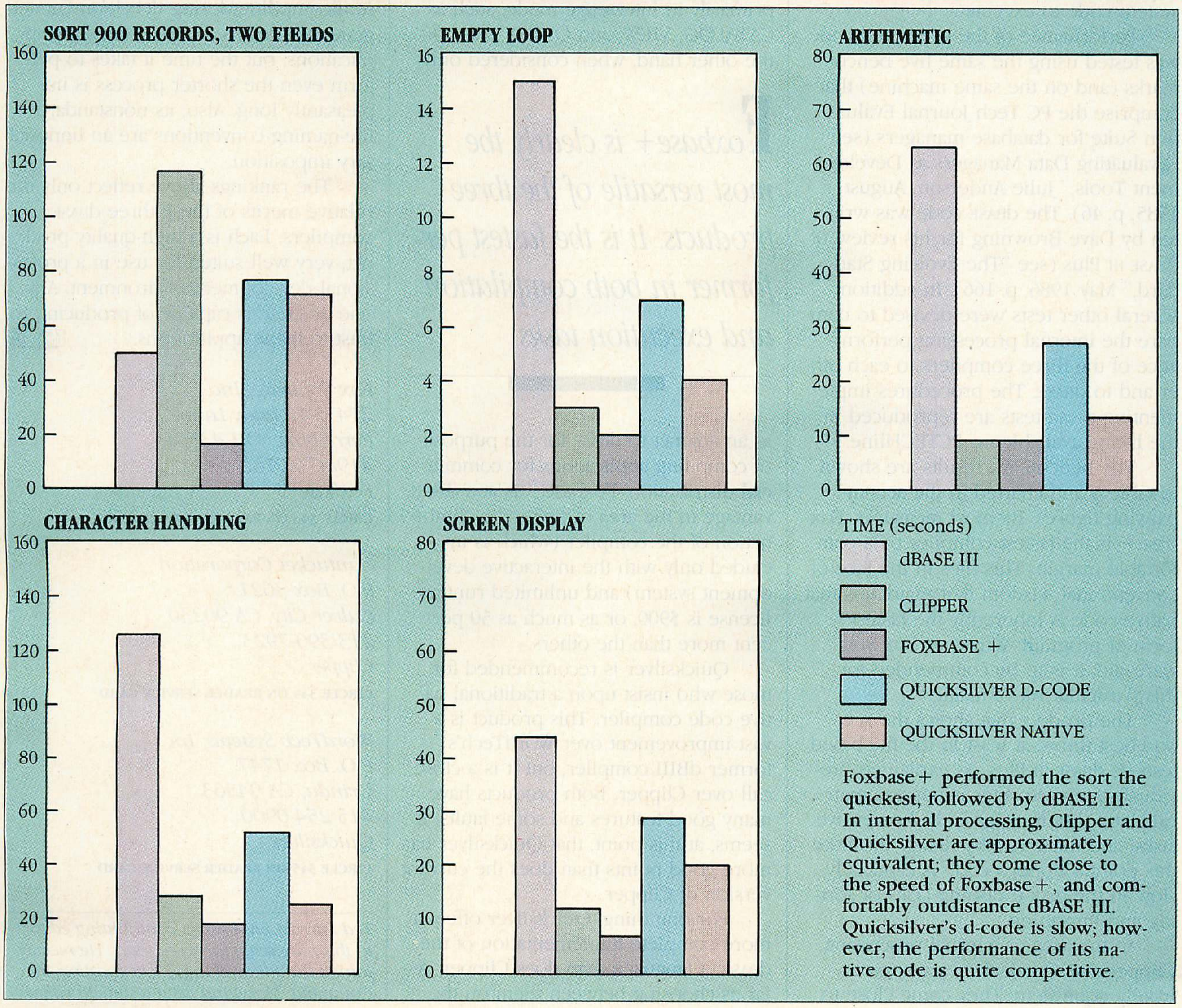
TABLE 5: *Benchmark Performance*

PRODUCT	AVG. TO DATE	ASHTON-TATE dBASE III	NANTUCKET Clipper	FOX Foxbase+	WORDTECH Quicksilver d-code	WORDTECH Quicksilver Native
STANDARD DATABASE TASKS						
Add 900 records to an empty database table	182	45	156	25	50	49
Index table on two fields (7 bytes)	53	14	11	7	5	6
Document and tally codes from one column	52	49	38	36	43	40
Mass change of one column (28 rows of 900)	22	5	2	2	4	4
Extract selected records to create a text file	11	2	2	2	1	1
ADDITIONAL TESTS						
Sort 900 records, two fields		50	117	16	76	71
Empty loop		15	3	2	7	4
Arithmetic		63	9	9	27	13
Character handling		126	28	18	52	25
Screen display		44	12	7	29	20

All benchmarks were run on an IBM PC/AT (6 MHz) with 640KB memory.
The tests were run in an 8MB partition on a CMI 20MB disk under DOS 3.0.

By most measures, Foxbase+ is the fastest by a comfortable margin. The runner-up, at least in the file-based tests, is dBASE III.

FIGURE: *Additional Tests*



Foxbase+ performed the sort the quickest, followed by dBASE III. In internal processing, Clipper and Quicksilver are approximately equivalent; they come close to the speed of Foxbase+, and comfortably outdistance dBASE III. Quicksilver's d-code is slow; however, the performance of its native code is quite competitive.

silver was Microsoft LINK version 3.05, which comes with version 4.0 of MASM. It ran considerably faster than the Phoenix PLINK86 included with Clipper.

The times turned in by Quicksilver for creating .EXE files are lengthened by the fact that the linker runs out of memory, even on a system with 640KB, and needs to create a scratch file on disk. This occurs only if the program that converts d-code to object code automatically calls the linker, and not if the linker is called directly from DOS. It seems that the conversion program does not release enough memory before executing the linker; by that time it should have completed its tasks and should be able to relinquish most of its memory allocation.

The small code files produced by Foxbase+ are not directly comparable to the output of the other compilers. For the others, each output file contains all the code it needs to run as a standalone program, whereas a Foxbase+ file needs more than 300KB of runtime system code to execute.

Performance of the generated code was tested using the same five benchmarks (and on the same machine) that comprise the PC Tech Journal Evaluation Suite for database managers (see "Evaluating Data Managers as Development Tools," Julie Anderson, August 1985, p. 46). The dBASE code was written by Dave Browning for his review of dBASE III Plus (see "The Evolving Standard," May 1986, p. 166). In addition, several other tests were devised to compare the internal processing performance of the three compilers to each other and to dBASE. The procedures implementing these tests are reproduced in the listing available on PCTECHline.

The benchmark results are shown in table 5 and charted in the accompanying figures. By most measures, Foxbase+ is the fastest compiler by a comfortable margin. This flies in the face of conventional wisdom that maintains that native code is inherently the fastest form of program. Whatever Fox Software did, it is to be commended for this particular bit of magic.

The product that shows the second-best times, at least in the file-based tests, is dBASE III Plus. As explained previously, an interpreter is not automatically at a disadvantage in disk-intensive tasks, and these results clearly illustrate this point. Clipper's code is especially slow in the disk-thrashing tasks of sorting and importing.

In the area of internal processing, Clipper and Quicksilver are approximately equivalent. They come close to the speed of Foxbase+, and outdistance dBASE III comfortably. Quicksilver's d-code is the slowest, but it is meant for testing, not production use.

COMPILING ADVANTAGES

Foxbase+ is clearly the most versatile of the three products. Purists may scoff at a pseudocompiler, but users interested in speed and convenience, not theory, must be impressed. It is the fastest in both compilation and execution speeds; for the former, up to two orders of magnitude faster. Its interactive capabilities make it almost an integrated development environment combining a compiler, editor, and debugger. Moreover, it implements a version of the language that is the closest to the current version of dBASE III Plus.

Foxbase+ has two drawbacks. If considered as a replacement for dBASE III, it lacks some of the interactive features of the Ashton-Tate product, such as ASSIST, and does not implement some of the newer features, also useful primarily in interactive mode, such as CATALOG, VIEW, and QUERY files. On the other hand, when considered only as an adjunct to dBASE for the purpose of compiling applications for commercial distribution, Foxbase+ is at a disadvantage in the area of price: the combination of the compiler (which is included only with the interactive development system) and unlimited runtime license is $900, or as much as 50 percent more than the others.

Foxbase+ is clearly the most versatile of the three products. It is the fastest performer in both compilation and execution tasks.

Quicksilver is recommended for those who insist upon a traditional native code compiler. This product is a vast improvement over WordTech's former dBIII compiler, but it is a close call over Clipper. Both products have many good features and some faults. It seems, at this point, that Quicksilver has more good points than does the current version of Clipper.

For one thing, Quicksilver offers a more complete implementation of the dBASE III language than does Clipper. As far as choosing between them on the basis of extensions to the language, each user must decide whether Clipper's memory arrays and menu system are more desirable than Quicksilver's file opening capacity and windowing facility. Another consideration, however, is that Clipper is a more established product, and has more support from third-party developers of link libraries and other support products.

Other areas in which Quicksilver is superior are the breaking of the DOS barrier of 15 open files, more convenient concurrency control in a network environment, a better debugger, and vastly superior documentation. Its manual is good by any measure, and more so in comparison with Clipper's disorganized material spread over more than half a dozen sources.

Clipper offers more speed in the compilation-link cycle, but the programs it produces are the slowest of all the products tested, including dBASE III Plus, especially in disk-intensive activities. Quicksilver offers the option of semicompiling during development and generating native code for finished applications, but the time it takes to perform even the shorter process is unpleasantly long. Also, its nonstandard file-naming conventions are an unnecessary imposition.

The rankings above reflect only the relative merits of these three dBASE compilers. Each is a high-quality product, very well suited for use in a professional development environment. Any one of these is capable of producing robust, reliable applications.

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Ted Mirecki has been a contributing editor to this magazine for three years. He recently joined the editorial staff at its location in Columbia, Maryland, as a technical editor.

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PT47

*The benchmark procedure was adapted from "Benchmarking Database Systems: A Systematic Approach" by Bitton, DeWitt and Turbyfill, December 1983.

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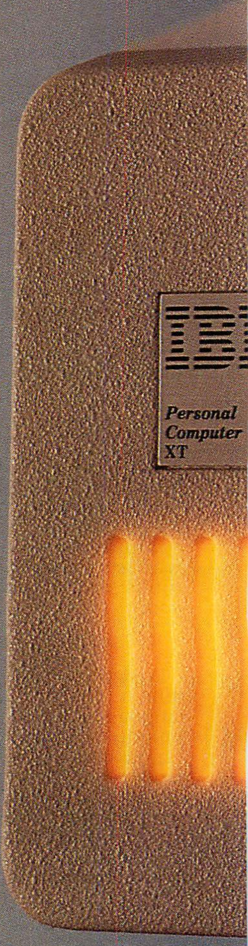
Speed Infusion

Part 2

A second group of accelerator boards for the PC are analyzed that incorporate an 8086 CPU operating at high clock speeds.

TED MIRECKI



PHOTOGRAPH • MARC DAVID COHEN

In the quest for better computing speed on the IBM PC, the simplest solution is to increase the frequency of the processor's clock. Six boards that implement this method were reviewed in "Speed Infusion, Part 1," (Ted Mirecki, February 1987, p. 126). But the brute-force application of megahertz quickly reaches the limits imposed by the response speed of the various integrated circuits (ICs) in the system. As a result, the speed increase possible with this approach is a modest 50 percent—barely noticeable. Exceeding the PC's speed limit by a significant margin requires more drastic action.

Two factors control the computational throughput of a computer: the clock frequency (the rate at which primitive microprocessor operations are performed) and the amount of work performed at each such operation. Once the first of these factors has been pushed to the limit, the next step is to increase the second. But the amount of work done at each clock cycle (or conversely, the number of clock cycles needed to perform a given operation) is an unalterable characteristic of a microprocessor. Therefore, the only way to increase this parameter is to replace the PC's microprocessor with another, more capable one.

Reviewed in this article are five boards that speed-up the PC by replacing the 8088: Microsoft's Mach 10, MicroWay's Number-Smasher/ECM with the MegaDOS memory management unit, Quadram's Quadsprint, and two boards from Univation—the PC Turbocharger and the Dream Board.

Several approaches are possible in designing an accelerator board around a new microprocessor. The most basic choice is which processor to use, as this determines other design criteria. Although in theory any microprocessor will do, the design is simplified and flexibility is gained by staying in the same hardware family. This means using one of the Intel microprocessors: an 8086, 80186, 80286, or 80386.

The next decision is whether the new CPU is to replace the original 8088 or be installed alongside of it. If the 8088 is replaced, the accelerator is known as an *emulator*, because the new microprocessor must emulate all


CLASS II

PHOTO 1: *Microsoft Mach 10*

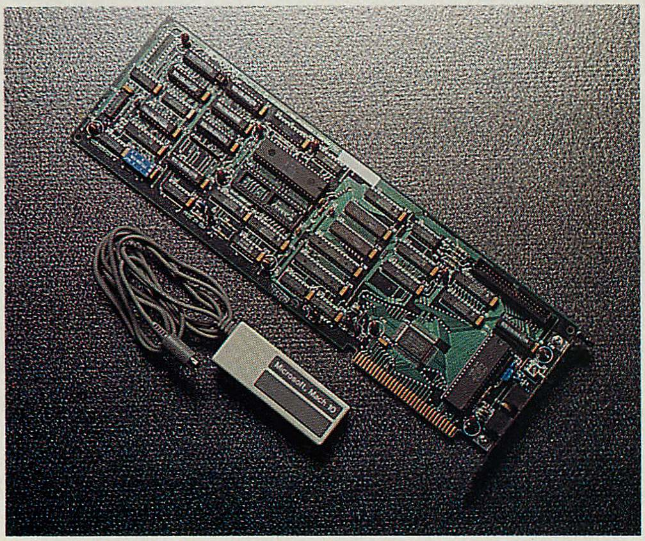


PHOTO 4: *Univation PC Turbocharger*

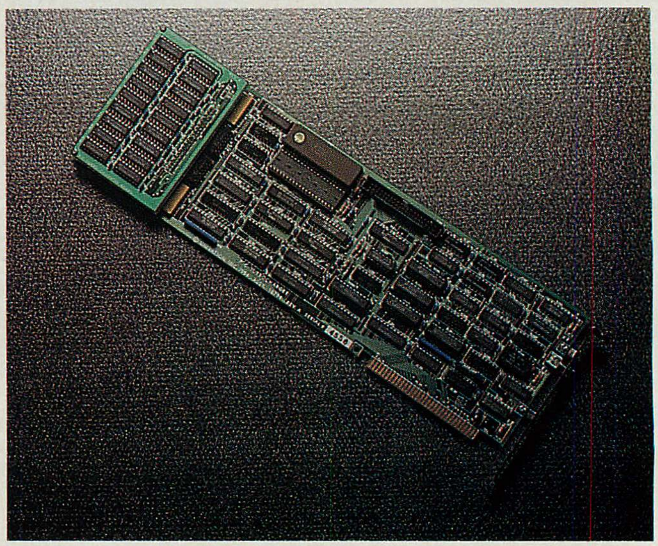


PHOTO 2: *MicroWay Number Smasher/ECM*

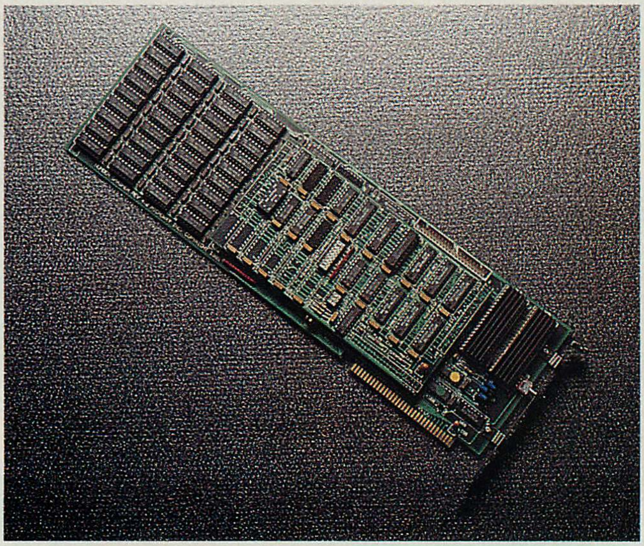


PHOTO 5: *Univation Dream Board*

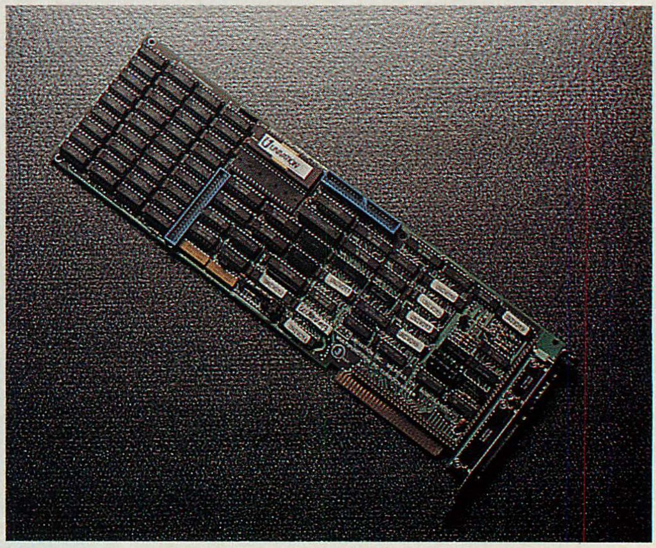
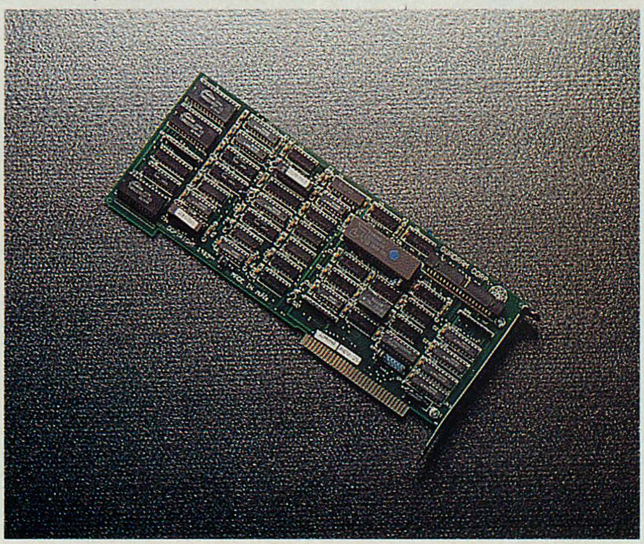


PHOTO 3: *Quadram Quadsprint*



PHOTOGRAPHS • BLAKESLEE/LANE

Two basic types of 8086 accelerator boards are represented: caching boards, which provide 4KB to 8KB of 16-bit memory, and full-complement boards, which provide at least 640KB of conventional memory on a 16-bit bus.

Photo 1: The Microsoft Mach 10 is a caching board with 8KB of high-speed, 16-bit memory. It incorporates an on-board mouse controller. The speed switch provides visual indication of the clock speed.

Photo 2: The MicroWay Number Smasher/ECM provides a full megabyte (1,024KB) of 16-bit memory, of which up to 1,016KB can be available to DOS.

Photo 3: The Quadram Quadsprint is a caching board with 4KB of high-speed memory. It does not have a mechanical speed switch; its speed is controlled by software.

Photo 4: The Univation PC Turbocharger board offers a full 640KB complement of memory accessible on a 16-bit bus.

Photo 5: The Univation Dream Board has 1MB of 16-bit RAM that provides 640KB of conventional memory; the rest is expanded memory, conforming to the specification.

of the functions of the original configuration. Of course, if the system is to run all of the same programs, the new processor must be compatible with the 8088 at the object code level. Therefore, this option is available only if the chosen CPU is one of the above-mentioned Intel models or a close compatible, such as the Nippon Electric Corporation (NEC) V20/30.

If the 8088 remains, the accelerator is called a *coprocessor*. This does not imply that the two CPUs do coprocess, that is, dynamically share the work load. In most cases, only one is active at any given time, and the switch between them is performed by the user. The advantage of this design is greater compatibility with the original PC configuration because an actual 8088 can be called upon when needed. The disadvantage is that the 8088 mode is available only at the original clock rate of 4.77 MHz, but an emulator can, to the extent of its compatibility, mimic the 8088, even at a high rate of speed.

A final design criterion (at least of those visible to users) is how to implement the interface between the accelerator's CPU and system memory. The whole point of adding a new CPU to the PC is to access memory 16 bits at a time instead of the system's original 8 bits, and to run at a clock rate that is not limited by the response time of the original memory chips. This requires high-speed memory and a 16-bit data bus on the accelerator board, but the designer has the choice of making all or only some of the system memory accessible at high speed.

To provide all of the memory on a high-speed bus, the accelerator card must allow for at least 640KB on board. Also, another 8KB or 64KB may be provided for copying the BIOS and BASIC code from ROM into high-speed RAM. Then, the only accesses to memory via the motherboard's 8-bit bus will be to the video buffer, unless the accelerator board also incorporates a video adapter.

If the accelerator is a coprocessor, it has its own memory separate from that of the original CPU on the motherboard. But if it is an emulator, only one CPU and one memory space are present, so the original memory is unused. Memory expansion cards can be removed, but motherboard memory must remain because the PC will not boot without memory on the motherboard. In a PC/XT, only one bank of 64KB must be left in place, but in an original PC, all four banks on the motherboard must be populated with chips if the memory space above it is not empty.

TABLE 1: *Features Comparison*

	MICROSOFT	MICROWAY	QUADRAM	UNIVATION	UNIVATION
MODEL	Mach 10	ECM	Quad-sprint	Turbo-charger	Dream Board
PRICE	$549	$1,199	$345	$995	$750
CLOCK SPEED (MHz)	9.54	9.54/11.62	9.54	9.54	9.54
MAX. ON-BOARD MEM.	8KB	1MB	4KB	640KB	2MB
SPEED CHANGE BY					
Toggle switch	●	●	○	●	○
Hot-key program	○	●	○	●	●
Transient program	○	●	●	●	●
I/O PORTS	—	C0H, E0H 1BEH, 2AEH	1F8H	C0H-DFH, E0H-FFH	C0H-DFH, E0H-FFH, 2x8[a]
OTHER FEATURES	Mouse port, Windows	DOS memory up to 1MB	—	—	EMS memory

● = *Yes* ○ = *No*

[a] *Where x is any one port 208H through 2F8H.*

The excessive use of I/O port addresses by some of these accelerators could cause compatibility problems—especially if they cannot be reassigned.

The alternative to providing a full complement of high-speed memory is to provide only a small area as a high-speed cache. This approach is based on the premise that in most programs, much of the time is spent in tight loops, and that a significant increase in overall speed can be achieved by storing only these loops, rather than the entire program, in high-speed memory.

A cache is typically implemented with 4KB to 8KB of high-speed memory to hold a copy of the information from the main memory, and an array of mapping bits that specify whether a particular address is or is not in the cache. At each read from memory, hardware logic tests the mapping array to determine whether the contents of the desired location are already in the cache; if not, the CPU is idled while the data are obtained at slower speed from main memory. The fetched information is made available to the CPU and simultaneously cached in the high-speed memory in anticipation of its subsequent reuse. When the same information is read again, the mapping array indicates that the data are already in the high-speed memory (this is called a *cache hit*) and it is fetched at high speed.

If the information is not needed again, caching provides no benefits. Caching does not improve the speed of writing to memory because, even if the target address is in the cache, writing is done to both high-speed and main memory simultaneously, and, thus, is limited by the latter's slower speed.

These variations in design provide several ways of categorizing accelerator boards: by the type of microprocessor, by whether they are emulators or coprocessors, or by how much high-speed memory they provide. In this series of articles, accelerators are classified by the type of processor. The first article described motherboard accelerators that use an 8088 or equivalent (Class I), this article reviews 8086 boards (Class II), and future installments will consider 80286 and 80386 boards (Class III). The general characteristics of the boards covered in the article are shown in table 1. Prior to examining each board individually, it would be useful to note some of their similarities and to review the characteristics of the 8086.

CLASS EMULATORS

All five boards run the processor at 9.54 MHz, obtained by doubling the motherboard clock frequency. Two of them (Quadsprint and Mach 10) have cache memory; the other three provide at least 640KB of high-speed memory on board. All five are emulators that replace the motherboard microprocessor; in all cases, a ribbon cable with a 40-pin plug at the end connects the board to the vacated 8088 socket. Because of the similarity of the two microprocessors, it is quite possible to fully emulate the 8088 with the 8086. Two basic differences exist between them. First, the data bus is 16 bits wide on the 8086 versus 8 bits on the 8088. Thus, each memory access on the 8086 can fetch a

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Number Smasher/ECM is 100% compatible with all hardware and software including EMS and EGA boards. The compatibility is a result of control: its speed is switch, keyboard or software selectable from 4.77 MHz to 12.0 MHz. Applications which have not been upgraded to ECM can still be run by setting DOS to 640K or 704K and using the memory above DOS for I/O enhancers.

Number Smasher/ECM runs floating point bound programs faster than an AT or any other 80286 based machine. In fact, Number Smasher's 12 MHz 8087 runs a factor of three faster than the standard 80287 on the AT, delivering up to 125 kflops. Software is included for RAM Disk, print spooler, and disk caching, which speeds up floppy and hard disks by a factor of 2 to 10!

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word instead of a byte. Second, the 8086 instruction prefetch queue is 6 bytes long, and the bus interface unit fetches the next instruction word when the execution unit removes two bytes from the queue. The 8088's queue is 4 bytes long and an instruction byte is fetched from memory as soon as a single byte is removed from the queue. In theory, this difference in the queue architecture can cause problems with self-modifying code, but in practice such problems seldom arise.

Microsoft. The Mach 10 combines an accelerator and mouse interface card in one slot. It is usually bundled with the Microsoft Mouse and the Windows package. For the price, it seems like a terrific bargain, but all is not as it appears to be.

The Windows package that includes the Mach 10 is the same as the one available separately, the mouse package is not. Its minimal documentation describes how to copy the driver files and how to remove the ball for cleaning. The software that comes with it contains drivers for mouse-aware programs, such as Microsoft Word; the menu-building and other software required to interface it to other programs are sold separately. Although the cost is only an additional $50, it is disappointing that not all components of the package are completely functional straight out of the box.

The Mach 10 is basically a good, if unspectacular, product. It is a caching board with 8KB of high-speed memory. Jumpers set at installation control whether all data (including BIOS and BASIC code from ROM) or only data from RAM gets cached. Disabling ROM caching prevents problems with programmed delay loops in early BIOS versions; the documentation suggests that ROM code dated prior to 10/27/82 should not be cached.

The speed of the Mach 10 is controlled only by hardware, not by hot keys or the execution of programs. Two speed switches are provided. The first is a two-position toggle switch that is mounted permanently on the board's rear bracket. Depending upon the switch position, the system will boot up in either fast or slow speed. The second switch is a momentary-contact push button mounted in an attractive plastic box with the Microsoft logo and a pilot lamp that lights up in high speed. Of the five boards tested, this is the only one that provides a visual indication of the system's speed. This switch mounts to the system unit and connects to the board with a cable that plugs into a receptacle on the rear bracket. When connected, it disables the toggle switch, and the system always boots up in slow speed. The board can be switched into high speed, however, by pressing the button, even before the completion of the power-on diagnostics.

The connectors for both the removable speed switch and the mouse are the new Microsoft InPort style; they resemble scaled-down DIN plugs of the type used to connect the PC keyboard. To avoid confusion between the two receptacles on the bracket, they are plainly labeled and keyed so that each will accept only its matching plug.

The documentation follows the standard Microsoft format, and is well done. Detailed drawings illustrate every phase of the installation, and the instructions are clear and complete. A useful index is included. The only complaint is that the tone is aimed at a user with much less experience than the typical installer of something as advanced as an accelerator board.

The speed of the Microsoft Mach 10 accelerator board is controlled only by hardware, not by hot keys or the execution of programs.

The installation and operation of the Mach 10 went smoothly. Because all of the board's functions are controlled by hardware switches, it has no I/O ports, thus avoiding this potential area of conflict with other hardware. It seems conservatively and carefully designed to stay within the capabilities of the host system, and although that means less than spectacular performance, it also means reliability.

MicroWay. The Number Smasher/ECM accelerator board contains a full megabyte (1,024KB) of RAM, in four banks of 256KB, 150-nanosecond (ns) chips. Installation is straightforward. Besides the cable connecting to the 8088 socket on the motherboard, a noise suppression module, consisting of a black plastic box containing resistors, is plugged into the 8087 socket. The 8087, if used, must be rated at 10 MHz, and resides on the Number Smasher. A toggle switch protruding through the rear bracket changes the clock frequency from normal to double the frequency of the motherboard. The boot-up speed may be either fast or slow, depending on the position of the switch, and the system speed may be changed at any time by flipping the switch, by hot keys, or by running a DOS program.

At boot-up, only 512KB of memory are recognized; using any more memory than this requires installing the MegaDOS device driver and then running the Memset program. Why the default was chosen at 512KB and not 640KB is not clear. It is possible to change this by setting switches on the Number Smasher, but the required settings are not documented. Users wishing to change the boot-up defaults of the board should contact MicroWay technical support for instructions.

The ECM in this board's name stands for expanded conventional memory; it is a feature of the MegaDOS device driver that allows setting the memory recognized by DOS to any value up to 1,016KB. The remaining 8KB is reserved for copying the ROM BIOS into the top of RAM. Memory above 640KB is normally reserved for system use—segments A000H and B000H for video display buffers, and segments C000H through F000H for expanded memory specification (EMS) page frames and ROM. The Number Smasher supplies duplicate memory addressed at these locations, and it dynamically switches between its on-board memory and the original memory on video and disk controllers. Access to EMS page frames is not automatically recognized; therefore, ECM memory must be limited to the segments below those containing EMS frames when EMS memory is being used. But this problem is minor compared with the next one.

Switching video buffers in and out of the memory space works fine for video output performed via BIOS calls, but cannot help in cases of direct writing to video adapter memory. As a result, many major applications, such as Lotus 1-2-3, dBASE III, Microsoft Word, and WordPerfect 4.1, will not run when DOS memory extends into the video segments. MicroWay supplies video drivers that fix this problem for two standard application programs: MicroPro's WordStar and Lotus 1-2-3 release 1A. Other programs that write directly to video buffers limit the DOS memory to 704KB, or 640KB with an IBM EGA.

It is possible to run Memset to reduce the DOS memory allocation before running one of these ill-behaved programs and set it back up thereafter, but with two problems. First, instead of moving the DOS top-of-memory pointer on the fly, Memset performs a warm re-

boot, losing any RAM-resident data and programs. Second, these types of applications are usually the very ones that would most benefit from a memory space larger than 640KB. But MicroWay does not aim the Number Smasher at the user needing large amounts of memory to run prewritten applications. Rather, this board is meant for systems running large custom-written programs, especially in the areas of scientific and engineering applications. For instance, ECM memory may be best for running a large FORTRAN program that needs 700KB to 900KB of memory, provided it uses well-behaved BIOS video calls.

Although the ECM scheme is less than successful, the Number Smasher's 1MB of RAM is not wasted because the memory above DOS can be used for other purposes. As previously mentioned, the contents of ROM may be copied into segment F000H of the on-board RAM; this may be limited to the 8KB of BIOS or may include the 32KB of the BASIC interpreter. Any memory remaining below the ROM image and above DOS may be used either for a disk cache or for a RAM disk.

In operation, the Number Smasher was not totally reliable. It pushes the PC's system to its limit, and occasionally beyond. At boot-up, spurious keyboard or hard-disk errors would crop up occasionally. The keyboard problems seemed to have no effect on the boot process and subsequent operations, but the hard-disk errors effectively would remove the hard disk from the system, so the system would boot up in cassette BASIC if the diskette drive was empty. On other occasions, after a successful boot-up the first keystroke would crash the system. Once up and running, however, no problems were encountered.

MicroWay also provides a way to run the Number Smasher at almost 12 MHz. This is done by installing a motherboard accelerator alongside the Number Smasher; the one supplied is a version of MicroWay's 87/88 Turbo reviewed in the previous article. The Number Smasher runs at either one or two times the motherboard clock rate, and the Turbo card runs the motherboard at either 4.77 or 5.81 MHz, giving a choice of four system speeds: 4.77, 5.81, 9.54, and 11.62 MHz. However, the Number Smasher/Turbo combination would not run reliably in the test system; often the system would crash when switched to a speed faster than 6 MHz. This was most likely the result of limitations of components on the motherboard, because the operation was more reliable in another, newer, PC with higher-rated components. As explained in the article on Class I accelerators, one of the requirements for installing the 87/88 Turbo card is a socketed 8284 clock-generator chip on the host system's motherboard. MicroWay also recommends an auxiliary cooling fan for 12-MHz operation.

The documentation, while not oriented toward the beginner, is seriously lacking in technical information for the more experienced user. The Number Smasher is a complex product, and some explanation of what it does and how it works would be beneficial to those apt to purchase it. The installation instructions are excellent, but no mention is made of several items: the I/O addresses used by the hardware (0C0H, 0E0H, 18EH, 2A8H), the fact that MegaDOS uses interrupt 61H or the purpose of 8 of the 11 switches on the board (these switches enable memory above 512KB at boot-up).

In operation, the MicroWay Number Smasher/ECM was not totally reliable. It pushes the PC system to its limit, and occasionally beyond.

All in all, when the Number Smasher works, it works well. But its lack of technical information and the unexplained intermittent failures that occurred during testing made using this product a frustrating experience.

Quadram. The Quadsprint is a caching board with 4KB of high-speed memory. As far as accelerators go, it is uncomplicated and reliable, but has the drawback that it does not support an 8087 coprocessor. There is no on-board socket for an 8087, and one left on the motherboard is ignored.

Switching between high and regular speed can be done only through software. Unfortunately, Quadram does not provide programs to perform the speed switching, but merely gives the BASIC OUT statements that produce high and low speeds.

An on-board jumper sets the boot-up speed of the board, but it also reverses the action of the speed-switching port. If the boot-up is performed at slow speed, writing a 1 to port 1F8H switches to high speed and writing 0 returns to slow speed. But if the jumper is set for booting at high speed, writing a 1 drops down into slow speed and writing 0 enters high speed.

The address of the speed-switching port can be changed by jumpers, but alternate addresses are not documented. Users who encounter problems are advised by the manual to contact Quadram's technical support for help.

The documentation regarding speed switching is not quite accurate. It states that the jumper and the ports disable memory caching only at low speed and enable it at high, but, in fact, the clock speed is also switched between 4.77 MHz and 9.54 MHz.

Otherwise, the documentation is acceptable. The installation instructions are clear and to the point, with useful illustrations. One good addition is Quadram's inclusion of a section on the theory of operation, although it is not well written. The extensive glossary that is included may bring new users more confusion than enlightenment, because it contains many terms and definitions not applicable to the Quadsprint. For example, the term *caching*, which is used extensively throughout the manual, is defined in the glossary only in terms of disk I/O caching, not memory caching as it applies in this instance.

Although no problems were encountered with installing and using the Quadsprint, it cannot be recommended enthusiastically. The do-it-yourself speed switching programs and the generally lackluster performance place it at a slight disadvantage in comparison with the other Class II boards.

Univation. Two accelerator boards from this company were reviewed: the PC Turbocharger and the Dream Board. The Turbocharger provides a full complement of high-speed memory in two banks of 256KB chips and two of 64KB, all of it rated at 150 ns. An option is available to address 64KB of this at segment F000H to hold a copy of the BIOS and BASIC ROM code. This is somewhat wasteful, first because the entire ROM code, including the BASIC interpreter, takes up only 40KB, and second because it is not possible to allocate only 8KB for a copy of the BIOS code. Users without interpreted BASIC must still lose all 64KB if they want to speed up BIOS operations. Further, the option to locate a bank in the ROM space is made with a jumper at installation, and cannot be changed without opening up the system.

Installation of the Turbocharger involves making the usual ribbon cable connection to the 8088 socket, and inserting a dual in-line package (DIP)

noise suppression unit into the 8087 socket on the motherboard. In addition, if the system is an early PC-1 model with a 64KB motherboard, two ICs on the Turbocharger must be removed and replaced with two others provided.

All three methods of speed switching are provided: a toggle switch on the rear bracket, a resident hot-key program, and a pair of programs that may be run from the DOS prompt or from a batch file. The speed at boot-up is controlled by the position of the toggle switch. Once running, however, no indication is given of the current system speed, and the position of the toggle switch does not help because its setting may have been overridden by software. Speed-switching was consistently reliable using any of the three modes.

The documentation is very good, with sections on hardware and software installation, operation, troubleshooting, and, most importantly, it includes a useful technical reference. The latter even includes the assembly language source code for the hot-key speed-switching program. The I/O port usage is documented, but no method is documented to change the port assignments in case of conflict with other devices. The number of ports to which the board responds seems inordinately large (see table 1), but the manual claims that these addresses "are not generally of use by software." IBM's hardware technical reference calls them "reserved."

Although its performance is not significantly different from the rest, the Turbocharger distinguishes itself by its superior documentation and reliable operation, making it the most trouble-free to install and operate.

Univation's second entry, the Dream Board, might be considered the ultimate multifunction board. It provides up to 2MB of high-speed RAM on a 16-bit bus: 640KB for conventional DOS memory, the rest for expanded memory complying with the Lotus/Intel/Microsoft standard. Optional daughterboards add a battery-backed clock/calendar and either two serial ports or one serial and one parallel port. A fully outfitted Dream Board adds a lot of power to a PC in a single slot.

The documentation is every bit as good as the Turbocharger's—the installation process is easy, yet the user is kept informed of what is being done. Before the Dream Board can be plugged into a system, an installation program is run to determine the current system configuration. The program's output guides the user in making the correct switch settings.

TABLE 2: *Benchmark Results*

	IBM	MICROSOFT	MICROWAY	MICROWAY	QUADRAM	UNIVATION	UNIVATION
MODEL	PC	Mach 10	ECM 9.5 MHz/	ECM 11.6 MHz/	Quad-sprint (ratio)	Turbo-charger (ratio)	Dream Board (ratio)
BUSPERF	0.045[a]	0.90	4.08	4.99	0.90	4.08	4.08
ATFLOAT							
No 8087	106	1.93	2.30	2.79	1.86	2.26	2.26
With 8087	22	1.69	2.00	2.44	—	2.00	2.00
VDISK ASSEMBLY	34	1.42	2.17	2.70	1.34	2.21	2.21
LOTUS 1-2-3							
No 8087	122	1.54	1.56	1.72	1.54	1.56	1.56
With 8087	41	1.35	1.39	1.39	—	1.39	1.39
dBASE SORT	119	1.21	1.38	1.38	1.19	1.35	1.35
WORD REPAG.	50	1.67	2.38	2.86	1.61	2.38	2.38

[a] *The numbers in this column are times in seconds for the base machine—an IBM PC with a 4.77-MHz 8088. The numbers in the remaining columns are percentages relative to the first-column unit figures (base 100), and represent the increase in PC performance yielded by the accelerator boards.*

Benchmarks improved twofold at best when the accelerator boards were installed.

As an accelerator, the Dream Board operates in a manner that is similar to the Turbocharger. One noticeable difference is that the copy of ROM, if desired, is kept in memory above 640KB and does not reduce the conventional memory available to DOS. Another difference is that the rear bracket carries two port connectors as well as the speed switch. As a result, the switch is placed up near the top of the bracket where it is inaccessible once the board is installed. This switch may be set at installation only, so its sole practical purpose is to determine the system speed at boot-up. However, it offers two other ways to change the speed: by running a program from the DOS prompt, or by installing a resident program that responds to hot keys.

Apart from its function as an accelerator, the Dream Board leaves much to be desired as an EMS board. Its Expanded Memory Manager does not implement the full set of EMS functions; it supports only the rudimentary ones numbered 1 through 8. (For a description of EMS functions, see "Expandable Memory," Ted Mirecki, February 1986, p. 66.) It is not clear whether the functions are missing because they were not programmed in the software, or because hardware-support is not there. Either way, it is a not a full implementation of the EMS standard.

Furthermore, the Dream Board's usefulness as a multifunction board is also somewhat flawed. Of the two kinds of daughterboards (serial-to-serial or serial-to-parallel), only one type will mount on any given Dream Board. Two models are available: one with connectors for two serial ports (one 9-pin and one 25-pin), and the other with connectors for one serial port and one parallel port. The I/O modules have no connectors of their own. Therefore, the commitment to the port configuration must be made at the time the baseboard is purchased, not when the daughterboard is added. The test unit came without the daughterboard.

Overall, the Dream Board cannot be recommended as highly as the Turbocharger. Although it is a capable accelerator, its functionality as an EMS board is seriously flawed. It might be worth considering for a system with a severe slot shortage, but in most cases, especially in a PC/XT or compatible, the same capabilities could be better provided by two or more boards (each tailored to a specific function).

ACCELERATED PERFORMANCE

The testing procedure for these board was the same as the that for the Class I accelerators as described in the first article of this series. The test system was an IBM PC-2 with 640KB (reduced to 256KB when testing boards with their own complement of high-speed memory), two diskette drives and a hard disk. The 8087 boards with a full complement of 16-bit memory, this performance can be directly measured by the BUSPERF program (published with the previous article, listings 1 and 2, pp. 156-157). The slight excess over 4.0 is due to lower overhead for dynamic RAM refresh, as explained in the earlier article on Class I accelerators.

For the caching boards, the results of BUSPERF do not reflect the effect of the high-speed cache memory, but only the speed of accessing the system's normal memory via the 8-bit bus at 4.7 MHz. This is a result of the straight-line sequence of instructions in BUSPERF, and points out the fact that a cache is useful only on second and subsequent accesses to a given memory location. For code fetches, this implies a loop that can fit within the cache memory.

When fetching code, the 8086 issues a bus transfer request for one word at a time, but the 8088 bus is capable of transferring only one byte per bus cycle. Thus, 2 bus cycles of 4 clocks each, or a total of 8 periods of the motherboard clock, must be performed for each request. In terms of the processor clock (which runs exactly twice as fast as the bus), it takes exactly 16 clock cycles to transfer each word from the main system memory, compared with 4 clock cycles for a transfer from high-speed on-board memory. From the processor's point of view, that is equivalent to 12 wait states per access. And if the bus cycle needs more than 4 clock cycles (for example, when transferring to or from an I/O port), each additional clock cycle on the bus inserts two processor wait states.

For reasons that could not be determined, both of the caching boards reviewed here (the Mach 10 and Quadsprint) inserted two additional processor wait states on every access to off-board memory. Their bus cycle is, thus, 18 processor clocks (instead of the minimum 16), resulting in a bus performance that is 10 percent lower than that of a standard PC.

The results of the benchmark tests are given in table 2. With the exception of BUSPERF, the tests are representative of practical applications performed on a typical business or development system. A brief description of each test follows; see the article on Class I accelerators for more comprehensive information.

ATFLOAT is a C program that performs a matrix multiplication. (See "Out from the Shadow of IBM...," Steven Armbrust, Ted Forgeron, and Paul Pierce, August 1986, p. 53. An updated version 1.02 of ATFLOAT is given in "Updating the Evaluation Suite," Steven Armbrust, Ted Forgeron, and Paul Pierce, March 1987, p. 70.)

The assembly test timed the assembly of the VDISK program supplied with DOS 3.2; it was converted from listing to source code format by a BASIC program (see "Same Language, New Architecture," Ted Mirecki, October 1985, p. 48). Microsoft's MASM version 4.0 was used; the input source file and output object file were both on RAM disk.

The Lotus 1-2-3 test generates a mortgage payment table for 80 different interest rates and 30 terms, using the Data Table 2 feature.

The dBASE test is a sort of 900 records of the author file from the sample application used for evaluating database managers (see "Evaluating Data Managers as Development Tools," Julie Anderson, August 1985, p. 46).

The word processor test is a repagination of a 19-page document with Microsoft Word. This was the only test that was timed using a stopwatch.

For operations with real numbers (ATFLOAT and Lotus 1-2-3), results are reported both with and without an 8087 numeric coprocessor. The Quadsprint does not support an 8087; the others provide an on-board socket for one. With these boards, an 8087 rated at 10 MHz is required. For the Number Smasher, a specially selected 8087 is required for operation at 12 MHz. Users wishing to operate this board with an 8087 at this speed should purchase it so equipped by MicroWay. Besides selecting a unit capable of operating at this clock rate, MicroWay also outfits it with a massive heat sink—a requirement for long-term operation at high speed.

A FULL COMPLEMENT

On several occasions during testing of these boards, a 301 keyboard error was indicated on boot-up in high-speed mode; this never prevented the system from coming up, and did not seem to affect its operation thereafter. This may be a warning that the PC is stressed to its limit, or may be only an anomaly of the keyboard controller.

As expected, the boards that provide a full complement of high-speed memory provide somewhat better performance than that of the caching boards. Although the difference is quite obvious in the measured results, it is barely noticeable in practice. With their lower prices, the caching boards provide respectable value—with some reservations. The Quadram Quadsprint does not support the 8087 and does not provide speed-switching programs, and the Microsoft Mach 10 does not provide full documentation and software support for the mouse. For these reasons, and not because of any inherent disadvantage of caching boards, neither one can be recommended.

At 9.5 MHz, the three full-complement boards provide almost identical performance. The MicroWay Number Smasher/ECM is a distinctive product for specialized applications, specifically scientific number-crunching chores requiring more than 640KB of memory. The 12-MHz capability, although almost unnoticeably different from operation at 9.5 MHz, can be useful when the last measure of performance matters. Because this product pushes significantly beyond the original design parameters of a PC, it does have reliability problems. This accelerator board will run only in selected systems, so it must be carefully tested before a commitment is made. Users who need the particular benefits provided by the Number Smasher, and who have a system that is capable of accommodating it, will find few other alternatives.

The other two full-complement boards come from the same company—Univation. The Dream Board, although a capable accelerator, is not satisfactory in its other functions, specifically, its EMS memory provision and its I/O ports. The PC Turbocharger is the clear choice as a general-purpose Class II accelerator board. Its advantages are reliability and superior documentation; its appeal lies in its ability to speed up the operation of the PC under the widest variety of conditions.

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MicroWay
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Kingston, MA 02364
617/746-7341
Number Smasher/ECM
CIRCLE 340 ON READER SERVICE CARD

Quadram Corporation
1 Quad Way
Norcross, GA 30093-2919
404/923-6666
Quadsprint
CIRCLE 341 ON READER SERVICE CARD

Univation
1231 California Circle
Milpitas, CA 95035
408/263-1200
PC Turbocharger
Dream Board
CIRCLE 342 ON READER SERVICE CARD

Ted Mirecki has been a contributing editor to this magazine for two years. He recently joined the editorial staff at its location in Columbia, Maryland, as a technical editor.

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CIRCLE NO. 182 ON READER SERVICE CARD

A Multiuser Solution

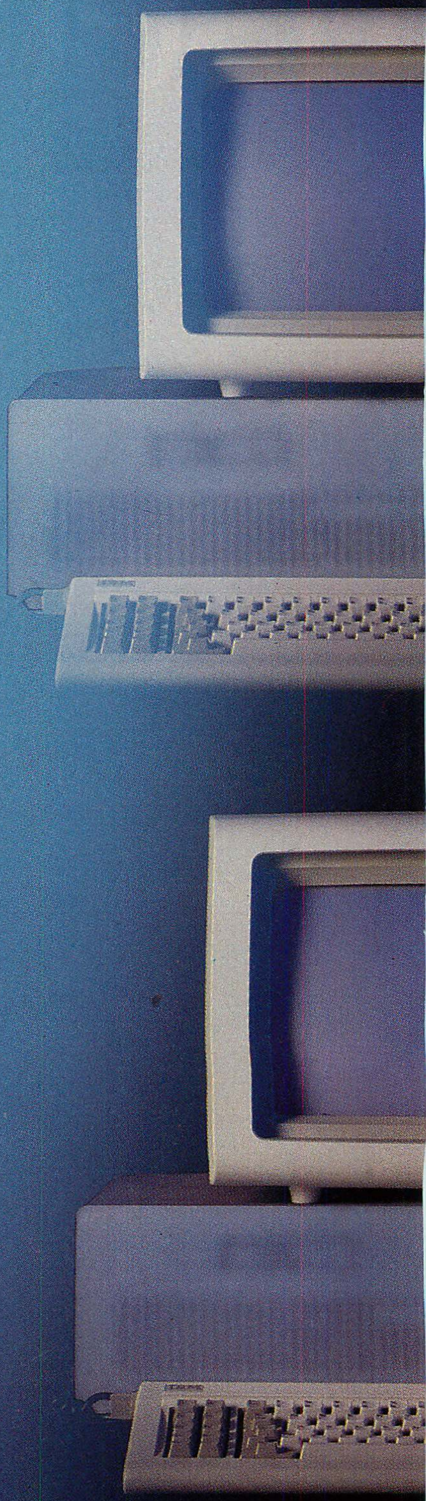
Taking the best from timesharing and networking, Classic Technology offers a practical solution for multiuser systems.

STUART BLAIR

Until the advent of the IBM PC/AT, sharing computers was practical only on minicomputers or mainframes. Rapidly increasing software applications for CPU cycles, memory, and I/O bandwidths still make the AT inadequate for many tasks. Nevertheless, broad categories of PC applications use only a fraction of the system capabilities that are available on an AT.

Users can benefit from a true shared PC environment—they can save money by sharing expensive computer components, control the storage and organization of data, simplify communications among system users, and increase system reliability. Companies are beginning to offer multiuser products that reside either on ATs or on PCs that have been enhanced with accelerator boards. These systems are based on three architectural avenues—timesharing, separate microprocessors, and networking. Classic Technology, Inc.'s Multiuser System is designed as a hybrid that incorporates timesharing and networking.

Proven timesharing technology has been borrowed from the minicomputer arena and recast to fit the capabilities and limitations of the PC microprocessor, with varying success. With short time slices and a fast enough CPU, each user perceives the illusion that his program is running continuously on a dedicated computer. Networking a collection of true PCs solves the PC software and video compatibility problems, as well as most of the throughput problems, but it increases the per-user cost. In some cases, the cost per PC of networking actually can exceed the price of the individual PC systems.



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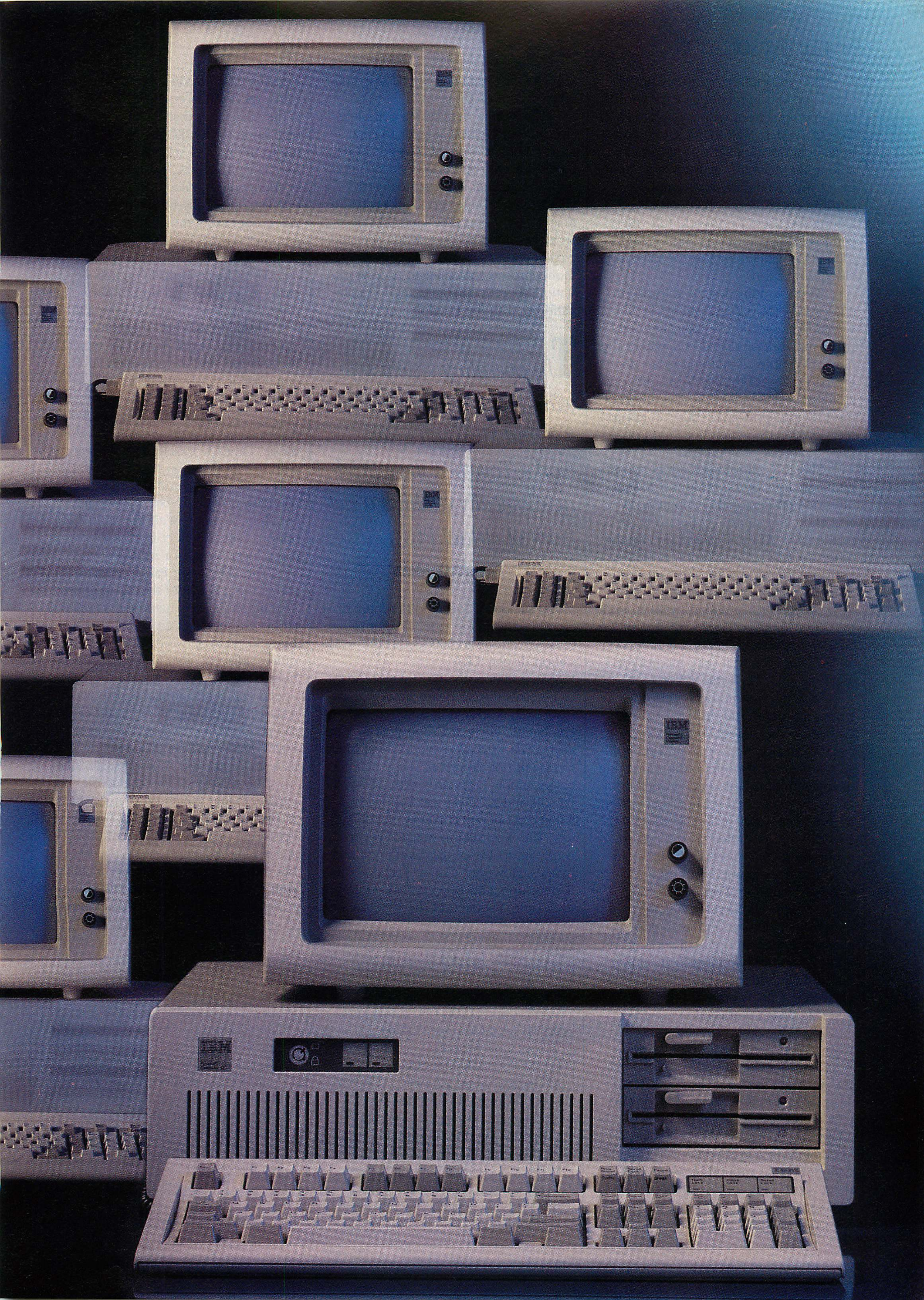


The proprietary hardware of the Classic system implements a traditional timesharing system with a single, fast CPU (a 10-MHz 80286), which is shared in an adaptive timeslicing algorithm among the currently active users. An array of fully IBM-compatible monochrome controllers is bank switched among the users to provide full video compatibility without having to suffer the performance penalties of software video emulation.

The operating system software includes PC-DOS 3.2 and Microsoft Networks. Together, these logically establish a network of virtual PCs, where the network "cable" is nothing more than the backplane of the PC. Transmissions along this cable adhere to definition of the ISO transport layer, but run at bus transfer speeds, which help minimize I/O bottleneck problems.

Classic Technologies offers two implementations of the Multiuser System, one for IBM Personal Computers, PC/XTs and compatibles (collectively referred to as XTs in this article) and the other for AT-class machines. Both systems are identical with one exception: the AT versions use the native 6- or 8-MHz 80286 CPU provided by IBM, while the XTs require a Classic 286 Speed Pak accelerator card containing a 10-MHz 80286 with zero-wait-state memory to augment the CPU horsepower.

Each person on the system uses a workstation with the display CRT and keyboard. The system supports two types of workstations. Classic Technologies supplies a complete unit consisting of an ergonomic (tilt and swivel) monitor, with a detached keyboard arranged in the AT-style key layout. Workstations also can be assembled by the customer using three components: an IBM-compatible monochrome monitor, an XT keyboard, and the Workstation Interface, a small self-powered adapter that merges the monitor and keyboard signals along with an optional serial port into a "network" connector. In either case, a heavy-duty, 25-pin shielded cable routes the signals between the computer and each workstation.

Network cables radiate to each workstation in a star topology from a Workstation Adapter card plugged into the XT motherboard. The Workstation Adapter serves as a controller for one to four workstations. By itself, this adapter contains the video and keyboard interface electronics for a single user as well as mounting positions for three small plug-in Workstation Modules, each of which supports one workstation. For larger systems, additional Workstation Adapters may be installed up to a limit of 16 users.

The system dedicates a complete alphanumeric video adapter to each user, complete with its own 6845 CRT controller chip and a 4KB video buffer. Both the adapter I/O registers and video refresh buffer are bank-switched. A special I/O port (see table 1) selects an active video adapter. When selected, a bank appears as a standard IBM monochrome controller to each workstation, thereby guaranteeing full compatibility with the PC alphanumeric video standard. Special differential drive circuitry allows the video output signal to be driven up to 500 feet to the workstation display CRT.

The operating system software includes IBM's PC-DOS 3.2 and Microsoft's Networks. Together, these products logically establish a network of virtual PCs.

In addition, the Workstation Adapter receives the keyboard input signals from each workstation unit. Any XT-compatible keyboard should work, but keyboards with AT-style electrical interfaces will not. However, many manufacturers supply keyboards with AT key layouts and XT electrical interfaces, which do operate correctly.

The Workstation Adapter is currently incapable of displaying graphics images. However, Classic Technologies is developing an EGA (enhanced graphics adapter) version of the Workstation Adapter based upon the Paradise Systems, Inc.'s PEGA controller chip. This is the same chip that is used in Paradise's AutoSwitch EGA card. By adjusting to the type of software that each user is running, the Workstation Adapter then will be able to automatically emulate any of the following modes of video operation: monochrome, color graphics (CGA), EGA, Hercules monographics, and Plantronics graphics.

The Classic Multi I/O controller card can provide private I/O ports dedicated to each workstation. Coupled with a Workstation Adapter, this controller contains four serial ports, one for each workstation, and a clock-calendar circuit. Classic workstations include an onboard serial-to-parallel converter; a toggle switch on the rear of the workstation selects between serial or parallel mode. Other workstations assembled with the Workstation Interface can tap only the serial port, unless they are configured with an external serial-to-parallel converter. With the Multi I/O option, users 500 feet from the host can run a local printer or mouse.

The 286 Speed Pak accelerator card forms the nucleus of the XT multiuser system, and also is marketed as a standalone product. Driven by a 10-MHz Intel 80286, this two-card module requires adjacent slots in the XT motherboard. (An 8-Mhz version of the 286 Speed Pak is also available, but was not tested.) In addition to the faster CPU, the accelerator contains a socket for the 80287 Numeric Data Processor, as well as a socket for the XT's 8088 CPU that must be relocated onto the accelerator card. A toggle switch on the rear panel of the card allows switching between operating in 8088 mode (standard speed) and 80286 mode (turbo speed), but the system must be powered off to shift gears. The 286 Speed Pak will be reviewed and compared with other

CLASSIC MULTIUSER SYSTEM

XT Base System: $2,595
10-MHz Speed Pak CPU (1MB RAM)
2.5MB RAM Memory Module
Workstation Adapter
MS-NET; Classic Operating System

AT Base System: $2,495
80286 Daughterboard Memory Management Unit
4MB RAM Memory Module
Workstation Adapter
MS-NET; Classic Operating System

Expansion options
Workstation Module: $195 (up to three per Workstation Adapter)
Workstation Adapter: $495 (one to four additional users)
Workstation Interface: $155 (for custom-built workstations)
Classic Workstation: $495 (includes built-in serial or parallel port)

Both the XT and AT base systems support two users if a CGA is used for the PC's display; only one user is supported if a monochrome display is used.

TABLE 1: *I/O Port Usage*

I/O ADDRESS[a]	FUNCTION
100	Memory manager control
102	Memory bank select
110-11F	Multi-I/O 8259 controller
330-334	Memory bank enable/disable
340-34F	Workstation card 8259 controller
370	Video RAM bank select
372	Multi-I/O bank select
3FO-3FF	Memory address configuration

[a] *I/O addresses are given in hexadecimal.*

These I/O port addresses control the custom memory management, keyboard ports, and video controllers; these addresses cannot be reconfigured.

cards in an upcoming article on 80286 accelerators for the PC.

The 286 Speed Pak contains 2.5MB 16-bit memory, expandable to 5MB on an additional card. The memory organization is proprietary to Classic; the system cannot support EMS memory expansion cards. An on-board memory management unit permits the system to create isolated 640KB *partitions* for each workstation, in which are contained a private copy of DOS and the application program for each user.

In addition, the XT's BIOS routines are copied into 16-bit RAM for faster execution. This technique of using IBM's BIOS guarantees a high degree of compatibility, although some device timing loops in the BIOS are reportedly patched after being loaded into RAM to provide proper performance with the accelerator. If an IBM computer is not used, the BIOS is not copied into faster RAM, and the performance advantage, therefore, is not realized.

A typical four-user XT-based system consists of these components:

- An IBM PC, XT, or Classic-approved compatible, with hard disk
- One 286 Speed Pak, a processor accelerator module containing an 80286 10-MHz CPU, and 2.5MB RAM
- One Workstation Adapter, a video controller card capable of supporting from one to four users
- Three Workstation Modules, small piggyback video controllers that mount on the Workstation adapter for users two through four
- Three workstations (displays and keyboards), in addition to the local display and keyboard provided with an XT

In an XT system, this relatively small configuration may require an upgrade from the standard 130-watt XT power supply. A PC system that is equipped only with the standard 62.5-watt supply certainly requires an upgrade. If the system is equipped with any additional option cards, then it probably will require an expansion chassis because with the piggyback cards and cables, the XT chassis is quite full.

The main difference between XT and AT implementations of the Multiuser System is that ATs do not use the 286 Speed Pak and RAM expansion hardware. Instead, a small Memory Management Unit daughterboard is attached at the AT's 80286 CPU socket, and a 4MB memory board is plugged into a bus slot. The Workstation Adapter and workstations themselves are identical to the XT configuration.

SYSTEM ARCHITECTURE

The system's proprietary hardware has been engineered to support two standard operating system software components, IBM's PC-DOS and Microsoft's MS-NET, which are coupled together by Classic's multitasking kernel. The system addresses both performance and compatibility issues by cloning an imaginary network of virtual PCs within one computer. These virtual PCs operate within their 640KB memory partitions carved from the system's 2.5MB to 16MB of memory, and function as workstations or as the network server.

The server partition manages most of the shared resources such as disks, directories, and printers. Because this network is physically a single timesharing system, it contains only one server to operate all shared devices. To conserve hardware resources, the server partition has no assigned console, although for diagnostic and configuration control purposes any workstation can be used as a console for the server partition using the NSWAP command.

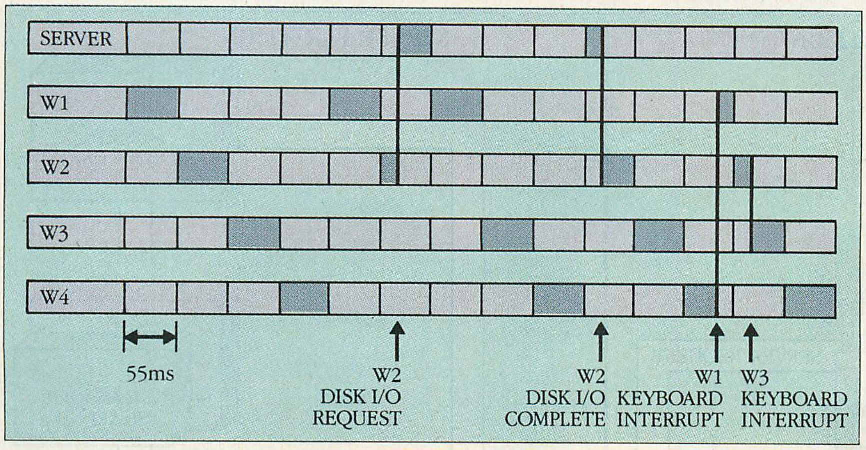
The remainder of the virtual PCs operate as network workstations, each running programs for a single user. In essence, the workstations are configured as "diskless PCs" with 640KB of RAM, a console (video and keyboard), and a copy of DOS and MS-NET. Although the entire system is controlled by a multitasking kernel, each workstation partition runs only in single tasking mode. In other words, non-interactive batch programs (other than the spooler supplied with the operating system) cannot be run in the background. Unlike disk-based workstations on a network, the Classic workstations depend on the network server to perform all file reading and writing, as well as most printing. As the server is dedicated to managing shared resources, it cannot run application programs for users.

To provide the complete compatibility required for most PC software, Classic must run in the 80286 real mode. This means that ill-behaved or experimental software run by one user potentially can crash the entire system. Although memory management hardware provides separate memory partitions for each workstation, a program still can corrupt critical memory locations or I/O port addresses used to control multiuser operations.

All of the partitions share a single copy of the XT or AT ROM BIOS and BASIC, in addition to the multitasking kernel. The BIOS and BASIC are the standard ROM firmware modules loaded into 16-bit RAM for improved performance, so that compatibility should not be a problem. The kernel module, called XPORT.EXE, consists of three components: the multitasking timeslice algorithm, an I/O monitor, and the network transport function used to communicate between the partitions. The ROM BIOS and BASIC modules occupy their normal memory segment beginning at F000:0H, while the kernel resides at address E000:0H in the XT implementations and at D000:0H in ATs. Numerous I/O port addresses also are used by the hardware, and are documented in table 1.

A workstation partition's unique memory address space consists of the memory between 0 and 9000:FFFFH, plus the video memory at B000:0H. Whenever a partition has the CPU, it will be mapped into the processor's address space at the above-mentioned addresses. To provide isolation from user modification of low-memory interrupt vectors, a rarely-used 80286 feature is exercised that allows the interrupt vector addresses to be located at an address other than zero. Classic's software relocates the interrupt addresses into

FIGURE 1: *Timeslicing Operation*



The CPU is rescheduled on each tick of the 18.2-MHz system clock, called a timeslice. Workstations are normally serviced in 1-2-3-4 order. Keyboard interrupts give a workstation immediate CPU time. Requests to the server are expedited by having the workstation yield the remainder of the timeslice to the server.

kernel memory that remains at the same location (E000:0H for an XT, D000:0H for an AT) regardless of the active partition.

The kernel contains a process that monitors all of the software and hardware interrupts in the system and determines which partition should handle each one. For example, the video display interrupt (INT 10H) is executed within the current workstation partition, while keyboard hardware interrupts, which could be generated at any time by any of the keyboards, are handled in the kernel. Certain I/O devices can be configured to be non-shared, such as a modem port dedicated to one of the users. Interrupts from such a device are examined and then passed along to the proper workstation partition.

The timeslice algorithm controls the sharing of the CPU cycles among the partitions thereby solving a difficult problem in an elegant way. Multiuser operating systems generally use a combination of two methods to determine when to give CPU time to an application. The first method is to set a maximum time that an application can use the CPU; if it is not voluntarily relinquished by this maximum time, the operating system forcibly changes to another application. The second method is to change applications whenever the current application requests a potentially time-consuming I/O operation. Programs normally make this known indirectly with a system call that requests an I/O service from a device that is not yet ready to transfer data, such as a keyboard. It is through this system-call mechanism that multiuser operating systems determine which programs are really waiting for input or output, and therefore are idle.

However, single-user computers based on PC-DOS (as well as most other single-user operating systems) typically allow application programs direct access to all devices; in these systems there is no memory or I/O protection at all. PC-DOS application programs frequently take advantage of this environment to provide higher performance or some degree of concurrency of task execution. The benefits outweigh the costs here, because unused CPU cycles are free. When no input data are available to process, these programs often look for something else to do. For example, when waiting for the next keystroke, Lotus 1-2-3 will update a clock window on the screen, a seemingly innocuous and trivial task, yet one which entirely consumes the available CPU time. Similarly, WordStar never waits for the next input keystroke, but rather alternates between checking the keyboard status for "next character available" and checking the printer port for room to output the next character from WordStar's internal spooler.

These programs can easily deceive the system into believing that they are productively active, when in fact they may be accomplishing little or nothing. In that case, even inactive user partitions would receive a full timeslice, degrading the performance of users doing productive processing.

The Classic timeslice algorithm addresses this problem in an adroit fashion. As a general rule, the CPU cycles are divided into short bursts by each tick of the system clock. These bursts are called *timeslices* and have a duration of about 55 ms. The timeslices are allotted one at a time to each partition in turn, followed by the next partition, for all workstations and the server. This fundamental algorithm provides an even distribution of CPU cycles to each partition. If n is the number of workstations, $(n + 1)$ is the number of partitions including the server, and c is the network management overhead factor, then each workstation receives the following share of CPU time, t:

$$t = \frac{(1 - c)}{(n + 1)}$$

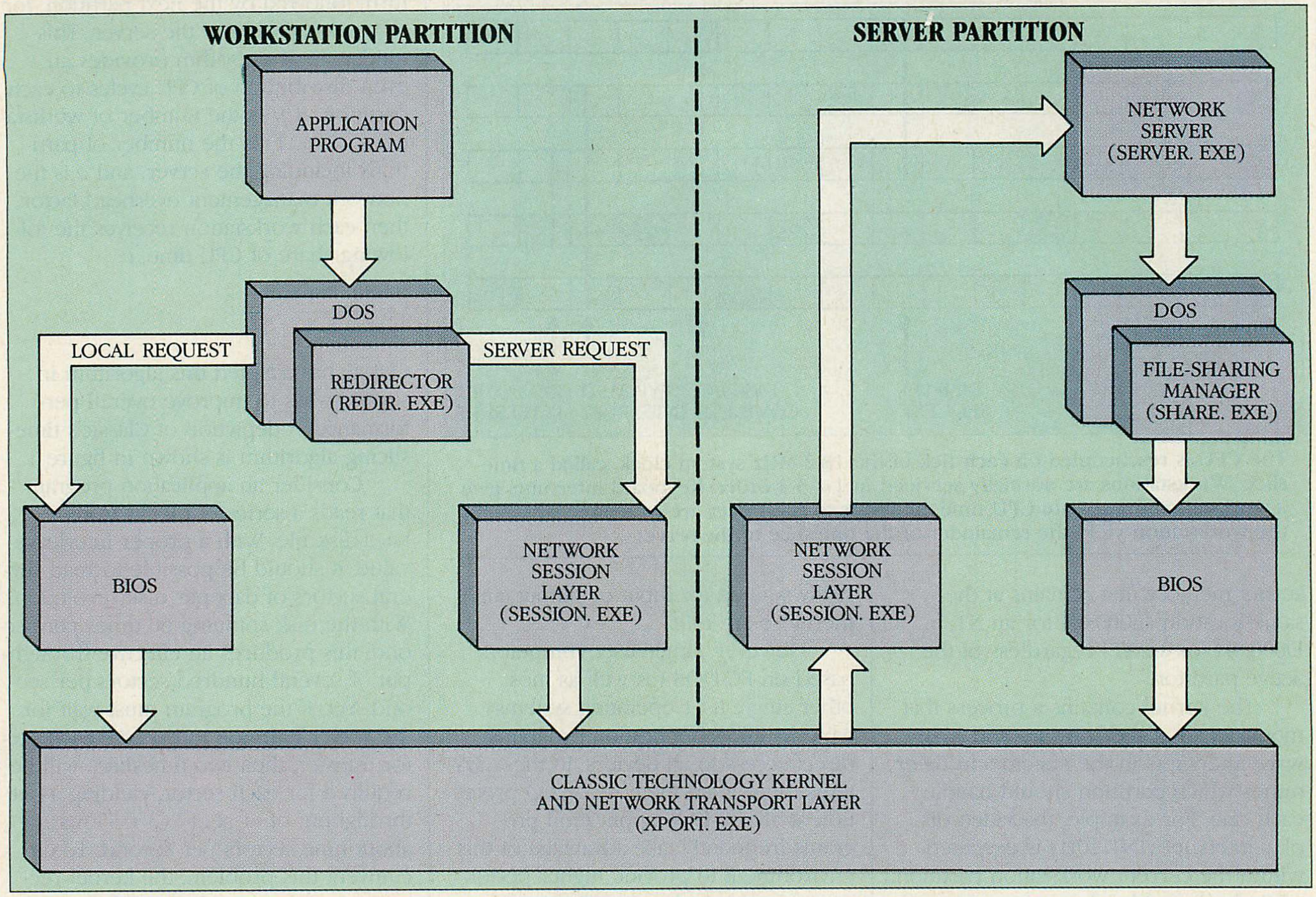
Classic has adapted this algorithm in several ways to improve overall performance. A depiction of Classic's timeslicing algorithm is shown in figure 1.

Consider an application program that reads a series of blocks from a hard-disk file. With a proper interleave value, it should be possible to read several sectors of data per disk revolution. With the disk spinning 60 times per second, this produces an effective throughput of several hundred sectors per second. Yet, if the program must wait for the server partition to execute each sector transfer, then two timeslices will be required for each sector, yielding a net throughput of (1 sec) / (2 * 55 ms) or about nine sectors per second. To circumvent this problem, the kernel recognizes when a workstation queues a server partition request and then borrows time from the current timeslice for the server to execute that request immediately. This eliminates the delay inherent in waiting for the next normal server timeslice for each disk transfer.

The kernel also recognizes when an application is continuously scanning the keyboard status with an empty keyboard buffer. After a few seconds, the CPU dispatcher begins to skip over this partition, gradually decreasing its CPU allocation to zero. Thus, when a user stops using the workstation, the CPU cycles are reallocated evenly to the other partitions. Since the timeslice allocation is restored to the partition when the next keyboard interrupt is received, this redistribution algorithm is fully automatic and transparent to the idle user. The other users simply notice improved performance whenever fewer workstations are active.

The dispatching algorithm is further configurable for Lotus 1-2-3 and Symphony users. Since these programs maintain a clock window on the CRT by calling the DOS Get Date and Get Time functions, they appear to the kernel to be doing useful work; hence, they continue to receive their full share of CPU

FIGURE 2: *System Software Diagram*



REDIR.EXE and SESSION.EXE handle server requests and are part of Microsoft Networks. SHARE.EXE, provided with PC-DOS, manages file sharing. Classic's component, XPORT.EXE, contains the hardware interface, timeslicing, and the network transport layer.

time. The manufacturer supplies a batch file that informs the dispatcher that a Lotus-like program is running, so it can switch to the next partition when date or time data are requested from DOS.

Although resident programs can be used by a workstation, Classic places some restrictions on them. Unfortunately, popular programs such as Borland's SideKick and SuperKey violate these restrictions. All programs must use BIOS interfaces, rather than direct hardware operations, to poll the keyboard. Also, a resident program must not depend on always receiving the 18.2/second clock tick. A clock-tick interrupt for a workstation occurs only during a workstation's own timeslice. If some other workstation has the timeslice, the resident program will not receive the tick. Resident programs can get a reliable tick count by using the standard IBM BIOS "ticks since midnight" doubleword at 0:46CH (correctly maintained by Classic).

SOFTWARE COMPONENTS

The MS-NET software that is provided by Classic also serves as the foundation for IBM's PC Network product. IBM has enhanced PC Network with certain desirable facilities, such as peer-to-peer communications (through NetBIOS).

Both PC-DOS 3.1 and 3.2 are supported by Classic and run without any patches. Each partition including the server contains a private copy of DOS. In the workstation partitions, each instance of DOS is responsible for handling non-shared resource usage functions such as process creation and termination, memory allocation, console I/O functions including ANSI terminal emulation via the ANSI.SYS video device driver, and file I/O to any local disk drives. Usually, local file I/O is limited to accessing a small RAM disk volume, which is stored within the 640KB memory partition, because the real disk drives must be shared.

The standard single-user DOS capabilities in the workstation partitions are augmented by three DOS extensions: the file sharing (SHARE.EXE), I/O redirection (REDIR.EXE), and session (SESSION.EXE) modules. The first of these extensions is distributed on the standard PC-DOS distribution diskette, while the latter two modules are components of MS-NET. All of the extensions are loaded as terminate-and-stay-resident (TSR) modules and are linked into DOS by way of software interrupt vectors. Each one of them is intended to be accessed by routines within DOS, rather than directly from application programs. This is consistent with the layered network service philosophy of the Open System Interconnection reference model. Figure 2 gives a schematic representation of how the operating system modules interrelate.

The SHARE.EXE module contains the support logic DOS requires for file sharing and diskette swapping protection. It introduces four *file-sharing modes*: Deny Read/Write, Deny Write, Deny Read, and Deny None. Deny Read/Write unconditionally forces exclusive access to a file, and fails if the file is open anywhere else in the system regardless of the usage mode. The Deny Write and Deny Read modes protect a file from being written or read by another program. The Deny None mode

places no restrictions on read or write access to file. This open mode updates a shared database file simultaneously from several partitions.

When a file can be concurrently written by several processes, some mechanism other than the open mode must be used to prevent "collisions" that can destroy the validity of the data. DOS provides a record locking system call that temporarily protects a contiguous region of a file by excluding other processes from reading or writing in that region. To be effective, the programs all must contain logic that properly locks either the entire file or an appropriate subset. Multiuser applications such as Ashton-Tate's dBASE III PLUS and Microrim's R:base 5000 contain this type of record-locking logic and work well within the Classic system.

The function of the redirector module is to recognize I/O requests for remote resources and reroute them to the network server. Both file I/O and printer character stream I/O redirection services are provided. The redirector examines file pathnames in the DOS calls OPEN, CREAT, as well as the directory and disk management functions to determine if a request should be executed locally or on the network. Local requests, such as RAM disk I/O, console I/O, and process creation and termination, are simply returned to the local DOS for execution.

Eventually, the redirected request arrives at the server. In a true network, the server would queue requests from all of the partitions and execute them on a first-in, first-out basis, finally returning the results to each originating redirector module when available. Here, however, it appears to the network software that disk requests are executed immediately upon arrival in the server, eliminating the need for any queuing. Shared printer requests generate character streams that also are redirected to the server, where the streams are stored in spool files.

Notice that although no physical network cable exists in this system, all of the underlying OSI network layers nevertheless are properly represented. Remote I/O requests from an application are trapped by the redirector and communicated over the session layer virtual circuit (layer 5). Sessions move data from one system to another with the assistance of the transport (layer 4), network (layer 3), and data link (layer 2) layers, which are all implemented concisely within the kernel. The lowest network layer, the physical layer, is actually the processor data bus.

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By Dick Erett, President of Software Security

Inventor and entrepreneur, Dick Erett, explains his company's view on the protection of intellectual property.

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Software protection must be understood to be a distinctively different concept from that commonly referred to as copy protection.

Fundamentally, software protection involves devising a method that prevents unauthorized use of a program, without restricting a legitimate user from making any number of additional copies or preventing program operation via hard disk or LANs.

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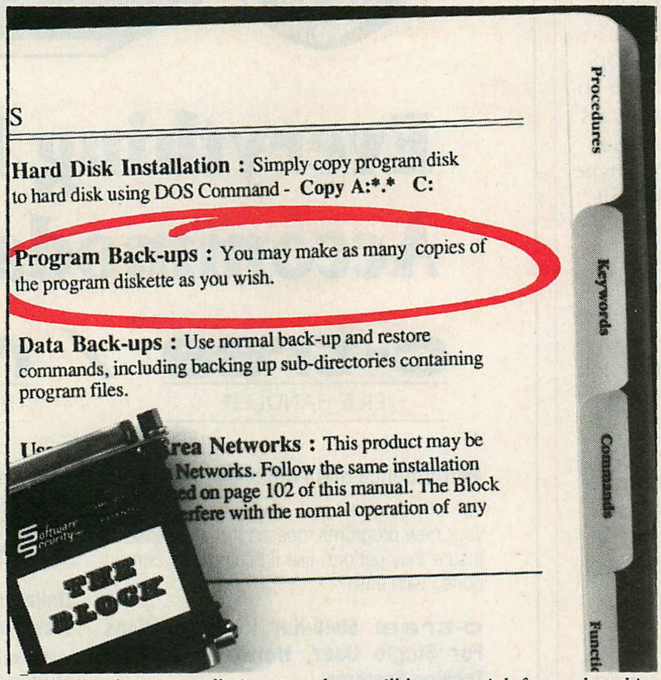
Software protection is at a crossroads and the choices are clear. You can give product away to a segment of the market, or take a stand against the theft of your intellectual property.



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SYSTEM MANAGEMENT

The server partition manages all of the shared resources in the system, including directories, printers, and disk drives. Rather than executing application programs and COMMAND.COM, this partition runs a dedicated network management program, SERVER.EXE. This routine accepts workstation requests to open, close, read, and write the shared resource files.

In addition, the server maintains a console display that is normally swapped into the background, meaning that it is not displayed on any of the workstation CRTs. The console queries system status and enters system management commands. It can be retrieved into the foreground by running the command NSWAP at any workstation. However, it cannot be returned to the background except from another workstation console, which can be inconvenient. Fortunately, the server console does not need to be accessed frequently by the system manager. Configuration commands to set up a particular server can be batched into an initialization file, OFFERS.I and processed each time the server is booted.

The system manager uses the SHARE command at the server console (not to be confused with the program SHARE.EXE, which manages the open file modes) to create a table of shared resources that are offered to the workstations. These resources, which are identified by a *shortname* of up to eight characters, can be password and permission protected to a degree. To share the diskette drive A:, the program library C:\BIN, a database directory C:\ACCT\DATABASE, and the shared serial printer attached to COM2: requires the following commands:

```
share floppya   = a:
share proglib   = c:\bin
share dblib     = c:\acct\database
share printer   = com2:
```

The shortnames **floppya**, **proglib**, **dblib**, and **printer** are arbitrary. Mapping the true pathname of a resource into the public shortname allows the system manager to be flexible in reconfiguring the server without modifying any of the applications in the workstation partitions. For example, as the hard disk C: nears its capacity because of growth in the inventory database file in the directory \ACCT\DATABASE, the manager can install a new hard drive D: and move the database directory there. In terms of software reconfiguration, the manager needs to modify only one share command; this is done by changing the DOS directory pathname and leaving the shortname **dblib** unchanged:

```
share dblib = d:\database
```

Workstations complete the mapping of the shared resources with another command, USE, that equates the resource shortname to an unused device name in the workstation. Thus, one partition might map the database directory to unused drive E:, while another might map the same directory to drive I:, and yet another might not attach that directory at all. The server printers, which are assigned shortnames such as **printer** and **printer2** (with the share command) are mapped to unused, typical printer device names such as PRN:, LPT1:, or COM2:. For example, a workstation might use the following collection of USE configuration commands:

```
use a:     \\server\srvra
use c:     \\server\proglib
use i:     \\server\dblib
use lpt1   \\server\printer
```

In conjunction with the SHARE commands listed above, these USE com-

mands provide the following resource mapping for this workstation:

Workstation Device Name	Server	Resource
a:	a:	(diskette)
c:	c:\bin	(directory)
i:	d:\dblib	(directory)
lpt1:	com2:	(serial printer)

Note that each partition, or system on the network, is assigned a network node name. The server partition is called SERVER, while the workstations are named CONSOLEA, CONSOLEB, and so on. These names can be reassigned, but without an electronic mail facility in MS-NET, the names only appear in the server status display.

The MS-NET printer spooler included with this system provides a substantially enhanced feature set in comparison to the DOS printer spooler, PRINT.COM, which it replaces. The acronym *spool*, derived from the term Simultaneous Peripheral Output On-Line, refers to the facility of printing concurrently with other program execution on a system. The spooler allows workstation users or application programs to generate printouts on one or more of the logical printers.

Character streams to each of the logical printers are automatically redirected to files in the system spool directory. When the application closes an LPT file, or terminates, then the spool file becomes a candidate for printing on a real printer owned by the server. In addition, a special TSR utility allows the user to release a spool file by pressing Ctrl-Alt-PtrSc. This technique prints the file without stopping the application. The collection of all the spool files waiting to be printed is called the *queue*. Normally, the server automatically prints files in the print queue on a first-in, first-out basis; however, several useful commands exist that enable a user to manage the queue.

Programs can generate spooled printer output through a variety of DOS, BIOS, and hardware interfaces. All of the normal DOS paths to the printer function correctly: DOS function 5 (the printer output), writing to file handle 4 (the standard printer device), and opening and writing to device LPT1. Programs also can print using the ROM BIOS print driver, interrupt 17H, and have the character stream automatically redirected to the spooler. Programs that issue output instructions to the printer port, however, will bypass the spooler entirely, and these programs will conflict with it if the spooler is trying to manage the device as well.

This spooler supports one or more physical printers for use in concurrent printing. Each workstation also may have several logical printers open simultaneously, thereby generating several different reports; this useful configuration facilitates certain multiuser business applications. For example, in a system consisting of four workstations and three physical printers, the spooler could be capturing 12 different print streams for later printing. Furthermore, the printers do not always have to be shared; they can be detached from the server and assigned to a workstation for direct, nonspooled printing. This satisfies the requirement of many applications that print special forms, such as invoices and checks, that must be printed immediately or may require special operator attention for forms alignment or security purposes.

THE SYSTEM'S HARDWARE

Regardless of whether the host computer is an XT or AT, the task of installing the Multiuser system hardware requires at least several hours and is rec-

ommended only for the technically self-assured. Although the manufacturer provides 26 pages of illustrated installation instructions, these directions include several errors, omissions, and unclear topics. Those who are not familiar with removing and installing chips and changing jumpers will find it worthwhile to pay an experienced dealer to set up this hardware.

The system used for this review was configured as a four-user computer, a size that is considered typical by the manufacturer. The multiuser hardware was installed in an XT originally configured with 640KB RAM, a Hercules video controller, an IBM diskette controller and single diskette drive, and an NCL/Centan Corporation's hard-disk controller and 20MB drive.

The hardware installation procedure involves four general phases: removing incompatible or unnecessary hardware from the host computer, installing the CPU accelerator (XT only), installing the workstation controller hardware, and assembling the workstations and attaching them to the host.

The Hercules card is incompatible with the bank switched video hardware and was removed first. Replacement candidates to provide video for the primary workstation are an IBM monochrome or CGA card, a Classic Monochrome Graphics Adapter, or a channel from the four port Workstation Adapter. In the reviewed system, a Workstation channel was used because it saved one slot in an already crowded chassis, saved power, and was readily available.

The combined +5 volt power requirement for the accelerator card, RAM expansion, and Workstation Adapter is approximately 9.8 amps. Combined with the XT motherboard and disk drive/controller requirements, this taxes the standard XT power supply's output limit of 15 amps. Because the accelerator card provides all of the system memory, Classic recommends removing memory chips in XT memory banks 1 through 3, and all memory chips on multifunction adapter cards to eliminate unnecessary power drain, or replacing the standard 130-watt power supply with a larger model suitable for the total configuration. An extraction tool is supplied for removing the memory chips.

The 286 Speed Pak accelerator card requires two adjacent expansion slots. The manufacturer recommends that they be located in the two full-length slots nearest the power supply. The 8088 is replaced with a ribbon cable and plug from the Speed Pak. The CPU is relocated to a socket on the Speed Pak to allow switching back to normal speed mode if necessary for compatibility or for diagnostic purposes.

Several jumpers and switches must be set on both the XT motherboard and the Speed Pak for proper operation, and herein lies some of the installation confusion. First, set the memory size switch on the motherboard to 64KB. Next, determine if the XT was manufactured after April 1986 (check the BIOS date code, using DEBUG to dump locations FFFF:5H through FFFF:CH). For post-April 1986 XTs only, jumper E2 on the motherboard must be opened. Also, the documentation states that jumper PWR ON ROM on the 286 Speed Pak is to be set closed for the older XTs and open for the newer XTs. This is incorrect; the reverse is actually true. Much later in the evaluation this misprint was determined to be the cause of both diskette format and intermittent hard-disk errors.

The third phase of installation is to assemble and install the Workstation Adapter(s). Each adapter supports from one to four users; instructions are provided for a single adapter card only. For larger systems, the installer should call Classic for proper configuration instructions for the additional adapters. Each Workstation Module daughterboard is snapped onto the Adapter. The Adapter card is then mounted in the slot farthest from the power supply, to minimize the video-clock noise coupling onto the Speed Pak cards. A connector box containing the cable interface jacks for the four workstations is mounted on the rear of the XT. The fit is very tight, and it may be necessary to leave the expansion slot that is adjacent to the Workstation Adapter empty.

An undocumented set of jumpers near the Workstation Adapter's edge connector selects the interrupt level used to read workstation keyboard input; it was factory configured for interrupt level 12. After several calls to Classic, it was determined that this should be reset to interrupt level 2 for the XT system. The IBM *PC/XT Technical Reference* manual indicates that this is the EGA or PC Network interrupt.

The individual workstations for the review were assembled from IBM monitors and keyboards. Signals from each monitor and keyboard are combined in a small workstation interface box. The box is powered by a 9-volt wall transformer and is attached to the Workstation Adapter's connector box with a 25-pin shielded cable.

Configuring the TaskMaster system software is straightforward. The hard

disk is formatted with either DOS 3.1 or 3.2, and the DOS system commands are installed into the directory C:\BIN.

The distribution software diskette contains a batch file called INSTALL that performs the remainder of the task, stopping to prompt for key parameters along the way. In doing so, it either sets up or modifies boot control files, such as CONFIG.SYS and AUTOEXEC.BAT. INSTALL will copy all of the TaskMaster software from diskette to the appropriate directories on the hard disk.

Certain resources can be allocated to the server or reserved for a user during the installation process. For example, each serial port can be marked shareable or private. In addition, the partition sizes assigned to each user can be varied from 256KB to 640KB each.

Finally, the INSTALL procedure creates the MULTI.BAT start-up file in the root directory, C:\. This command must be executed in order to commence multiuser operation. One possibility is to place it in the final line in AUTOEXEC.BAT.

A great deal of flexibility is provided for start-up initialization. The AUTOEXEC.BAT file contains only system startup commands. Commands that should be run by all workstations at start-up are placed in AUTOCMN.BAT. Start-up commands for each workstation are placed in files named AUTO*XX*.BAT, where *XX* is the letter designation (A, B, C, D) of the workstation, which is repeated a second time.

SCANT DOCUMENTATION

Three manuals are provided with Classic: the *User and Manager Guide*, the *Troubleshooting Guide*, and the *Applications Software Guide*. The manuals are not well organized and do not have indexes. Multiple readings of the manuals will probably be required to run the system successfully. Section headings in the tables of contents are only marginally useful guides to the information contained in a section.

The *User and Manager Guide* is a 140-page manual. The publishing of these two guides as a single volume is inappropriate because it contains much information needed only during installation and configuration.

Most of the *Manager Guide* covers the installation process discussed above. The incorrect documentation for the setting of the PWR ON ROM switch, also mentioned above, is an error that should have been corrected before the manual was released by Classic.

The *User Guide* is a scant 30 pages long; it covers the essential details of using the network commands to access shared resources and control the print spooler. An appendix lists the error messages that may be encountered, and suggests corrective action in some cases. Additional appendixes that discuss restrictions on BIOS interrupt 13H (the absolute disk read function), system calls for multiuser extensions, and hardware technical specifications.

The *Troubleshooting Guide* is a 23-page manual that outlines problem solving for the system, both hardware and software. It covers problems that may be encountered during installation, power-up, and operation. This guide should be used in conjunction with the *Manager Guide* during installation.

The installation and operation of specific products are covered in the *Applications Software Guide*. Some of the products that Classic does include instructions for are: BPI's General Ledger; Ashton-Tate's dBASE III PLUS, Multimate, and Framework; Lotus 1-2-3; WordPerfect Corporation's WordPerfect 4.1; MicroPro's WordStar; Microrim's R:base 5000; Data Access's DataFlex; mbp

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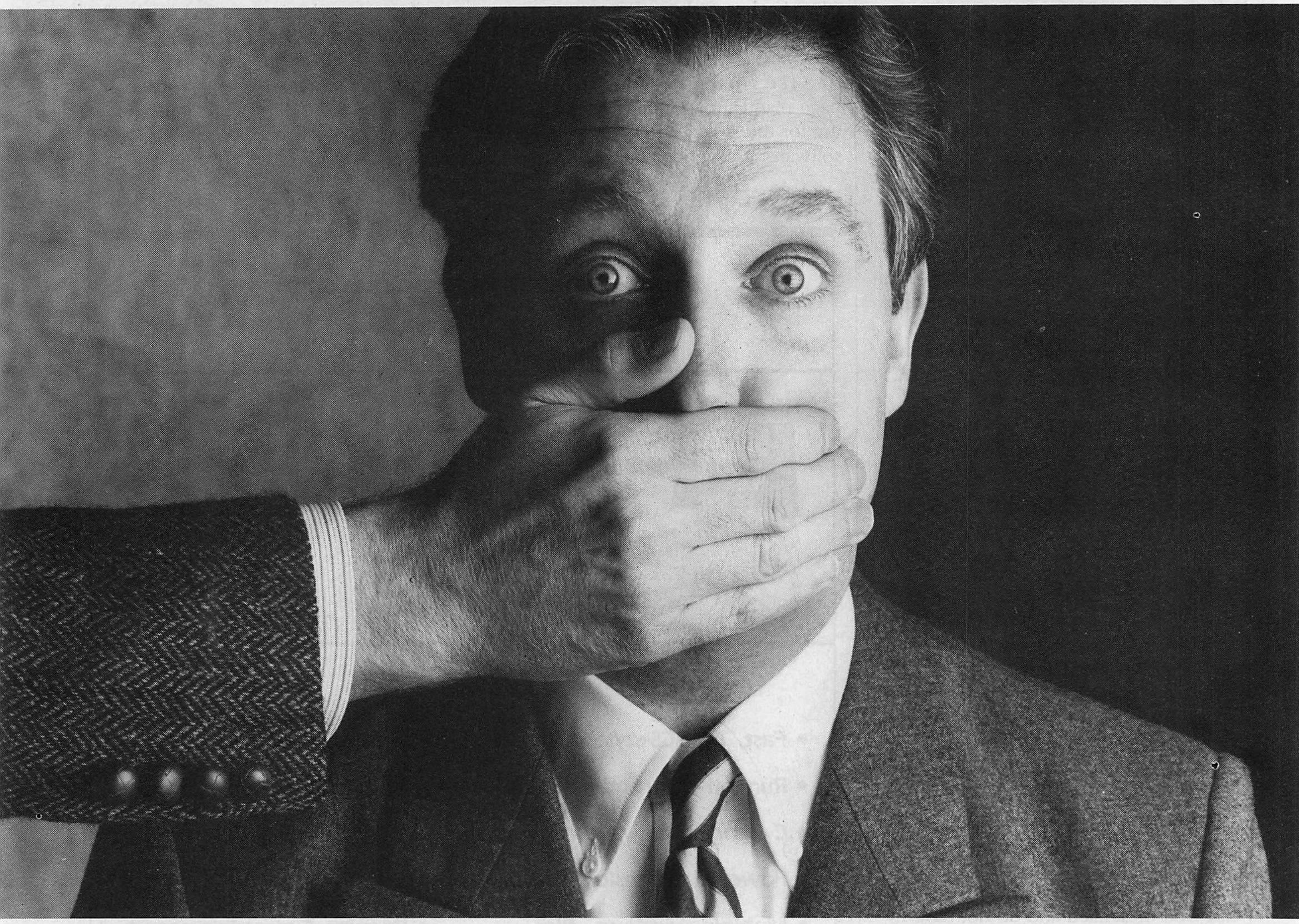

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TABLE 2: *Benchmark Results*

BENCHMARKS	W1[a]	W2	W3	W4
All TIMER	23	23	23	23
Idle Workstation	0[b]	31	30	31
WordStar 60 WPM	10	38	29	15
WordStar 120 WPM	22	39	22	9
WordStar File Load	17	28	26	21
Read Buffered File	17	13	31	31

All figures are percentages of CPU time used.
[a] *Designated workstation.*
[b] *For tests other than All TIMER, W1 was calculated as 100 − W2 − W3 − W4 − SO, where SO is the system CPU overhead derived as 8 percent in the All TIMER test.*

In most cases, the CPU time was fairly distributed among the workstations. The priority given to keyboard input keeps user response time acceptable.

COBOL, and the Smart Software Series. Changes or clarifications to the vendor's standard procedures are provided.

The best way to learn about the Classic system is to serve an apprenticeship under someone who has already installed and used one. The manuals will discourage many users from attempting a first-time installation. Once the learning curve has been conquered, with the aid of phone calls to Classic, subsequent installations should prove much less formidable.

OPERATIONAL TESTING

Both 50- and 500-foot workstation cables were provided with the review system, and while the 50-foot cables performed flawlessly, the 500-foot cable introduced several intolerable problems, including poor video quality. Video quality was very good at 50 feet, with no noticeable degradation from a conventionally-located PC monitor. At 500 feet, image degradation was noticeable. Single pixels were lost in either normal or reverse video, causing indistinct serifs on characters. Noise or transmission errors caused some pixels to flicker randomly on the Amdek monitor. At this longer distance, occasional keyboard transmission errors occurred.

On the XT, if a user attempts to use a diskette while others are operating the system, all of the workstations will lose keystrokes while the diskette is being accessed. This is because the memory management unit must "lock-in" one partition (CPU and DMA always transfer to/from current partition) while the diskette comes up to speed and transfers the data. This seems to be a design problem; keystrokes could be buffered in shared memory and transferred to the BIOS keyboard buffer when the partition is dispatched.

Classic indicated that this situation is not a problem, because users will normally use the hard disk exclusively in a multiuser environment. Nevertheless, there are legitimate uses for diskettes, such as new software release installation, restoring damaged files from backup diskettes, or transferring data or document files to or from other systems. Users do not expect to lose keystrokes for no apparent reason.

Much of the system's hardware does not come from IBM, therefore, the standard IBM diagnostics provide little help in identifying problems. This system needs a thorough set of diagnostic programs, both for the manufacturer and customer's benefit. For example, the first CPU board received for this evaluation was defective and caused occasional system failures and there was no reliable way to identify the problem.

Because the entire Classic system is essentially one computer and a single bus, it can be susceptible to problems with grounding. Improper grounds can cause shock when attaching cables to the network interface box. A disconnected workstation cable or disconnected keyboard sometimes causes the system to crash. If a workstation is unpowered, it can generate a high interrupt load, which prevents the entire system from booting.

The complete system has not yet received either FCC Class A (office) or Class B (home) certification. Customers could be held responsible for eliminating any unexpected radio frequency interference emanating from the workstation signal cables (which could act as excellent antennas for transmitting the high frequency video signals). Classic has indicated that it is in the process of obtaining both FCC and Underwriter's Labs (UL) certification.

Workstations do not contain a speaker and cannot generate beeps to draw the user's attention. The speaker in the host PC can be left operative, but Classic recommends that it be disconnected. Otherwise, any use of the speaker within a program at a remote workstation generates an unnecessary noise at the host PC.

TAKING THE TESTS

The operation of the timeslice algorithm is crucial to the performance of the Classic system. If situations such as busy-waiting for keyboard input are not detected correctly, performance will suffer greatly. A measurement program, TIMER.C, was created to determine the behavior of the timeslice algorithm under a variety of test conditions. This program is shown in listing 1.

The TIMER program examines the BIOS clock in low memory to determine the passage of time. Many factors affect the operation of the timer program, including CPU speed and C compiler optimizations. The constant CALIB was chosen so that the program reported 100 percent CPU usage when running as a single-user system. Although the BIOS timer tick actually steals time from a program running under DOS, it is not significant to the measurements. The same BIOS timer tick overhead exists in multiuser mode, and its effects can be safely ignored.

After calibration, the system was started in multiuser mode. The results of each performed test are summarized in table 2. The first test was to run TIMER on all of the four workstations to determine CPU usage when all workstations were compute-bound. As the results show, an equitable division of the CPU time was performed by Classic's algorithm; each received 23 percent of the CPU. In addition, the overhead of the multiuser operating system can be determined to be about 8 percent (using $100\% - 4 * 23\%$) for the CPU-bound case. In later tests, an overhead figure of 8 percent was used to derive the CPU percentage of workstation that was not running the TIMER program.

A second test measured the CPU used by an idle workstation. Workstation 1 was waiting for input at the DOS prompt while the remaining programs ran TIMER. CPU time was fairly divided among the non-idle workstations, and the idle workstation received no CPU time. A character typed at workstation 1 appeared immediately, indicating that CPU is given to the workstation as soon as it is needed.

The next two tests, WordStar 60 WPM and WordStar 120 WPM, attempted to measure the effect of keyboard input on the timeslice allocation. An operator entering text into WordStar was active

at one workstation, while the other workstations ran the TIMER program. Two measurements were taken, one with characters being entered at 60 words per minute (about 2 characters per second), and another with 120 words per minute. In both cases, WordStar received adequate CPU time to update information, although full-screen scrolling was sometimes performed in hesitant bursts of activity. The priority preference that Classic gives to programs that have just received keyboard input maintains a respectable response time. Such programs are rarely compute-bound, and can relinquish CPU time to other workstations after the keystroke has been processed. The partitioning of the remaining CPU time becomes unbalanced; whether this is a problem is largely application-dependent.

In the fifth test, WordStar File Load, a 33KB file was loaded and positioned at the end of the file. This took approximately five times longer in multiuser mode when all other workstations were running TIMER. However, this should be viewed as a worst-case performance because usually all other workstations would not be compute-bound at the same time. Therefore, the timeslices and elapsed time are still respectable.

The last test read a file that was small enough to be cached into the DOS buffers. One workstation continuously read through a small file until the end-of-file, then repositioned to the beginning and repeated the process. The percentage of CPU time used by this test was the same as in WordStar File Load, but the CPU distribution to the remaining workstations changed.

These tests indicate that the Classic Multiuser System can provide respectable response time for as many as four users. Using an XT as the foundation for Classic is not recommended. The need for an accelerator board, the resulting loss of bus slots, general admonitions in the installation manual about "noise," and the taxing of the power supply are some of the deterrents to an XT-based system. An AT-class machine, preferably one with high-performance characteristics, would be a better match. Classic has begun to sell its own 15-MHz AT compatible.

The Classic Multiuser System is an effective way to obtain many advantages of networks without the cost and performance penalties. It is a very capable platform for creating turnkey applications that involve stable software packages. In particular, network data managers should benefit from Classic's bus-speed network medium. By building upon the foundations of PC-DOS and MS-NET, Classic has made a large body of application software available for immediate and productive use.

Stuart Blair is the president of Stanford Software Institute, a software consulting and product development company specializing in DOS and UNIX operating systems.

LISTING 1: TIMER.C

```
/*
 *      timer:
 *
 *      This routine consumes CPU cycles, and periodically
 *      displays a CPU usage factor on the CRT.
 *
 *      The program increments a counter during an interval of time.
 *      The CPU usage factor is proportional to the value of that
 *      counter at the end of the time period.  An empirically
 *      derived calibration constant is used to scale the counter
 *      value to a percentage (from 0 to 100 percent CPU busy).  The
 *      percentage is displayed at the end of each interval.
 *
 *      The report time period is specified in seconds as the first
 *      argument in the command line.  To select a 5 second interval:
 *
 *           timer 5
 */

#define CALIB     550           /* calibration constant        */
#define TIMER     0x006C        /* rom bios TIMER_LOW offset   */
#define BIOSDSEG  0x0040        /* rom bios TIMER_LOW segment  */

main(argc, argv)
int argc;
char *argv[];
{
        long count;             /* raw CPU busy measure        */
        int  scale;             /* factor to convert "count" to */
                                /* a percentage of CPU busy.   */
        long round;             /* rounding correction         */
        long delay();           /* CPU busy timing routine     */
        int  time = 1;          /* default 1 sec report period */
        int  ticks;             /* "time" in system clock ticks */
        int  begin, end;        /* actual limit of sample period */
        long busy;              /* CPU busy percentage         */

        if (argc > 1)           /* alternate reporting interval */
            time = atoi (argv[1]);

        scale = CALIB * time;   /* scale factor for converting */
                                /* count to percentage of CPU  */
                                /* busy, for the specified     */
                                /* reporting period.  This is  */
                                /* the number of counts per 1% */
                                /* of CPU busy.                */
        round = scale / 2;      /* rounding correction value   */
        ticks = time * 18;      /* approximate number of timer */
                                /* ticks per report period, at */
                                /* about 18 ticks per second   */

        delay (1);              /* synchronize with system clock*/
        while (1)               /* forever */
        {
            begin = peek(TIMER, BIOSDSEG); /* actual start time */
            count = delay(ticks);          /* count thru interval */
            end   = peek(TIMER, BIOSDSEG); /* actual end time   */
            /*
             *  Due to the scheduling algorithm, the sample period
             *  may be several ticks longer than what was requested.
             *  Correct for this error, then convert to percentage.
             */
            busy = (count * ticks)/(end - begin);
            busy = (busy + round) / scale;
            printf ("busy = %d%%\n", (int) busy);
        }
}

/*
 *      Delay a minimum of "tc" ticks of the system clock, and
 *      increment a counter during this time period.  Return value
 *      of counter as a raw measure of the CPU time allocated to
 *      this partition.
 */

long delay (tc)
        int tc;         /* measurement interval is timer ticks  */
{
        int begin = peek(TIMER, BIOSDSEG);
        long count = 0;

        while ((peek(TIMER, BIOSDSEG) - begin) < tc)
            ++count;
        return (count);
}

/* Compile with -DMSC for Microsoft C, it has no peek() function */

#ifdef MSC
int peek(where)
        int far *where; /* treat segment:offset as a far pointer */
{
        return(*where);
}
#endif
```

TECH PC JOURNAL

Comdex System Builder Contest!

And the winner is...

Congratulations to Jim Eddings, DP Manager, Ithaca Industries Inc., Gastonia, NC, the winner of PC TECH JOURNAL's System Builder Contest.

Those of you who were at Fall COMDEX probably remember the System Builder Contest—the one that had over 4000 system experts and MIS/DP professionals going from booth to booth to complete their "chassis" with the hope of winning the system expert's "ultimate system."

PC TECH JOURNAL editor Will Fastie (left) congratulates SYSTEM BUILDER CONTEST grand prize winner Jim Eddings.

Grand Prize

The "ultimate PC system", determined by our contestants, is composed of:

	Reader Service #
• An Access 386 by ALR	291
• The Vega deluxe EGA board from Video-7	290
• A Princeton HX-12E EGA monitor	292
• Iomega's Bernoulli Box	293
• An ITT Qume Laser 10 Printer	294
• Omni Tel's 2400 HB modem	295
• Crosstalk	289
• Quarterdeck's Desqview	296
• Modula-2 from Logitech	288
• Knowledgeman/2 by Micro Data Base Systems	287
• AutoCAD by Auto Desk	297
• Fifth Generation's Fastback	298
• Lifeboat's Advantage C + +	286

Jim represents a typical PC TECH JOURNAL reader; a system professional in an end-user environment responsible for system integration, micro-to-mainframe communication, identifying needs, evaluating and recommending products, designing, building, and maintaining PC and larger systems, and training company employees in using these systems—a job made easier thanks to the information he gets every month from PC TECH JOURNAL.

First Prize

Intel Inboard 386/AT

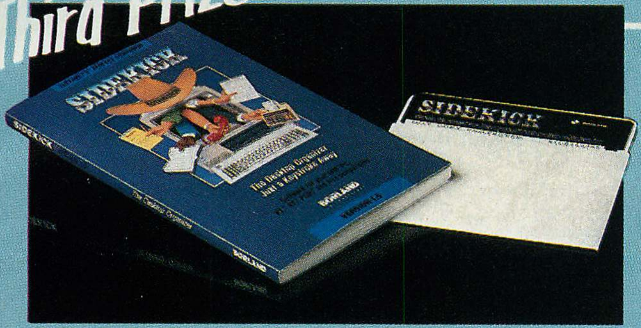
Mike Johnson	PC Systems Support Manager Trans Oklahoma Inc.

Second Prize

WordPerfect 4.2

Daniel F. Burm	President Woodson Computers
Edwin E. Sund	Sr. Engineer PC Weyerhaeuser Corp.
Alan Tipton	Systems Analyst Texas A & I University
Richard Hall	Director Dimensions West
Larry Shaw	PC Coordinator Nordstrom, Inc.

Third Prize



Borland SideKick

Jim Roberts	President Pied De Grue Systems
David Halpern	President Emanon
Frank Stein	Sett Manager Citizen Utilities
David McGibbon	Technician CAM-X Service
Stephen P. Richard	President RichComp
Paul Biddle	Director Lencar
Jim Davis	ADO USAF
Richard Busch	Systems Analyst T.I.S.
W.R. Renner	Owner Budget Buys
R. David Richards	President Microtech Systems

Runner-Up Prize

1 Year Renewal/Subscription to PC TECH JOURNAL

Dave McConnell	Vice President Sales Computer Resources Management
David Norris	Microsoft
Jay J. Levine	Director Computer Tax Price Waterhouse
Paul King	President King Computer Systems
Stephanie Levine	Manager Paramount Pictures Corp.
Bobby Williams	Owner Software Systems of Texas
Richard Messeder	Computer Applications Engineer Southern California Edison
Arthur G. Mulanax	Consultant A&S Computers
Gary Rittenbach	Director Walla Walla College
Mel Barnum	Manager, PC Services Maritz Inc.
Robert Ash	President Ameritel
Waleed Sophie	General Manager Oyster International
Roxanna D. Madson	Accountant ATMS
Rick Shindell	Owner Shindell Consultants
David E. Anselmi	C.E. Staff Officer US Army USA15E1C
Kenneth Avellind	Sr. Programmer Analyst Los Church
Janet K. Lang	Vice President O.S. LTD
N.W. Fuerst	Project Engineer Hughes Acpt. ED56
Karl Konnerth	Tech Specialist Syntex
C. Michael Bell	Consultant Technical Consulting
Roger Thompson	Owner Sunnyside Computers
Frank Bromberg	Sr. Director/Dealer Support Western Union
Cathy Miller	Software Development Medirec
Donald E. Orifia	President Micro Works Corporation
Nilsa Stensho	Planpart AB

In addition to congratulating Jim, we'd also like to take this opportunity to thank the COMDEX exhibitors who were kind enough to participate in the contest, and took the time to "install" the "components" involved.

System Unit
ITT – Xtra/286 ATW
Atronics International, Inc. – ATI System 286
Multitech Electronics Inc. – Multitech 900
Univation – Slimline
Televideo – TeleCAT-286
Advanced Logic Research – Access 386
American Mitac – Computitan
Cordata – AT Compatible
Toshiba America Inc. – Information Systems Div

Graphics Adapter Board
STB Systems – Multi Res
Mylex Corp – MYLEX EGA
ATI Technologies – EGA Wonder
Tecmar – EGA Master
Alps America – Image Enhancer
American Mitac – Mega Plus Graphics EGA Board
ATD – Zuckerboard – Monochrome graphics 1/2 card-Zuckerboard
Atronics International, Inc. – Mega Graph Plus
Paradise – Autoswitch EGA
Video 7, Inc. – Vega Deluxe
Everex – Graphics Adapter Board
Univation – Dreamboard

Graphics Display Monitor
Sakata USA Corp. – EGA Performer
Princeton Graphics – HX-12E
Aydin Controls – Patriot Enhancer

Add-in Expansion Memory
IDEAssociates – All Aboard 286
Univation – Dreamboard
Teleware West – Above Disk

Multi-Function add-in Board
Microway Inc. – Number Smasher EC/M
Applied Reasoning – PC Elevator 286
Univation – Dreamboard
Intel – Inboard 386/AT

Modem
BARR Systems – BARR 208AB MODEM
American Mitac – Mitac Modem
Omnitel – Internal Modem

Printer
Cordata – Laser Printer
Toshiba America Inc. – Information Systems Div
ITT QUME – Laser Jet
Citizen America Corp. – any printer

PC Communications Products
Tiara – TiaraLink
Fifth Generation – Logical Connection
Crosspoint System – Crosspoint 8
Videx – Bar Code Reader
Datacopy – JetReader and Model 730
Crosstalk Communications – Crosstalk
Micro Data Base Systems – MDBS III LAN
Star Gate Technologies – OC8000 Board
Kimtron – KT-7
Nestar Systems, Inc. – Plan 5000 File Service
WordPerfect Corporation – WordPerfect
Gateway Communications Inc. – Gateway

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Irwin Magnetics Systems Inc. – BACKUP
Tallgrass Technologies – Grasshopper/Back track s/w
Dynatech Computer Power, Inc. – Turn On
Flagstaff Engineering – 9-track tape
Iomega Corporation – Bernoulli Box
Mountain Computer, Inc. – Racecard 286, 47-MB Drivecard, Series 4000 40MB Tape Back-up System
Sysgen, Inc. – Sysgen Image
Xebec – 97TC
Plus Development Corp – HardCard 20M
Overland Data – Tape linx/9-track tape
Fifth Generation Inc. – Fastback
Maynard Electronics – MaynStream
Weltec Digital Corp

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Quantum Software Systems Ltd. – QNX
Xebec – Amnesia Board
Quarterdeck – Desqview

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Logitech, Inc. – Modula-2
Micro Data Base Systems – Guru

Data Manager
Data Languages – Progress
Data Access – Dataflex
Micro Data Base Systems – MDBS III, Knowledgeman-2
Zanthe – ZIM
UNIFY Corporation – UNIFY
Cosmos Inc. – Revelation
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Nantucket – Clipper
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WordTech

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STSC, Inc. – STATGRAPHICS
Autodesk – AutoCAD
Generic Software – GenericCAD
Foresight – Drafix 1

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Fifth Generation – Fastback
WalSoft – dFlow

Programmer's Utilities
Lifeboat – Advantage C++
Gazelle Systems – Q-DOS or Back-It
Microtech Research – C-Cross Compiler
Nostradamus, Inc.
Instant Replay, Pascal Plus, CPlus, Screen Genie, Word Genie, No Blink, DOS/BOSS, Turbo Plus
Opt-Tech – Opt-Scroll, Opt-Tech Sort

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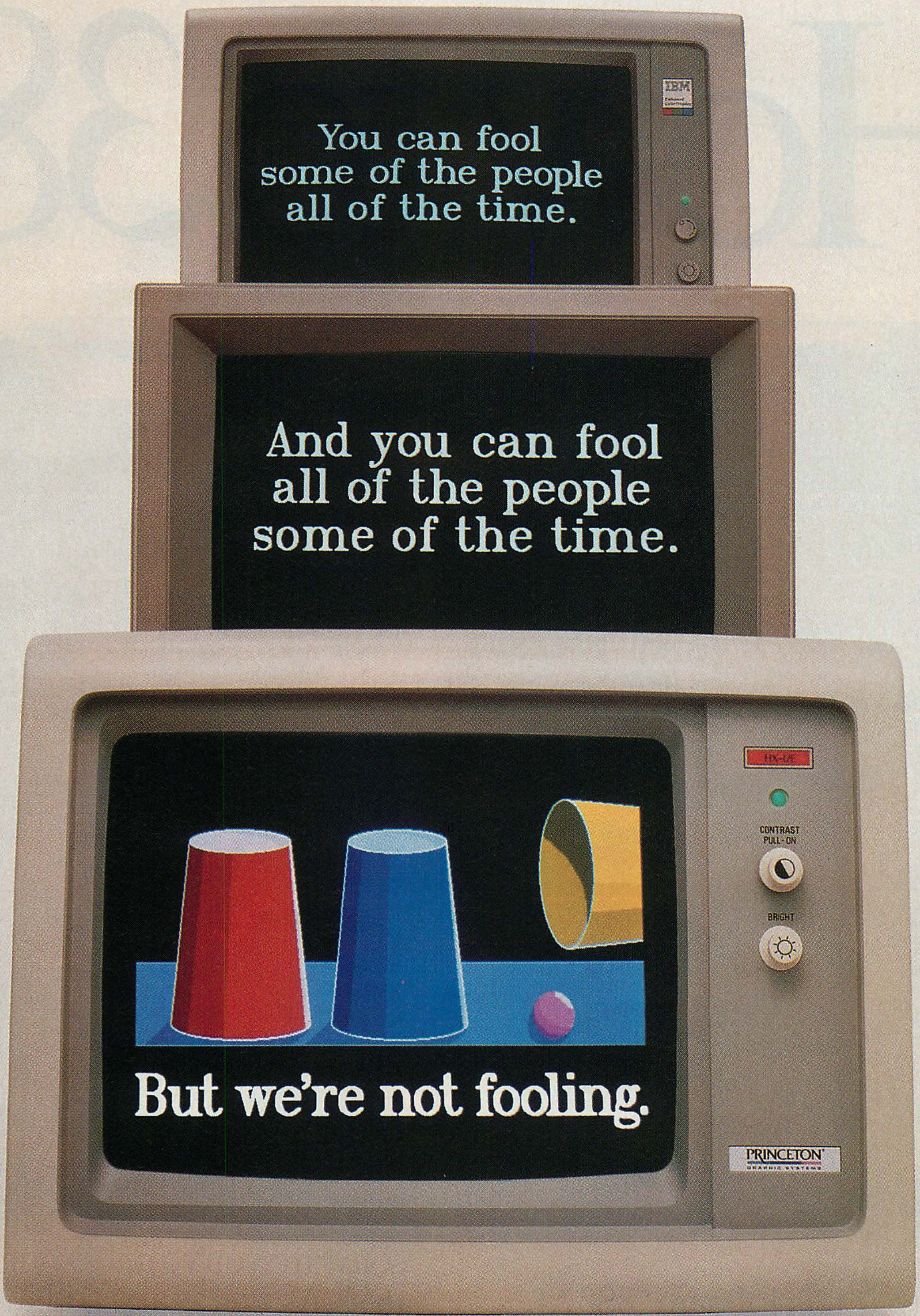
Persoft – Smarterm 240
Quadram – Quad 5251
CXI, Inc. – P-Cox Family
Information Technologies – Link-Up
Link Technologies, Inc. – PC Term
Gateway Communication Inc. – Gateway
IDEAssociates – IDEAComm 5251

TECH PC JOURNAL

And for those of you who didn't win… remember there's always next year!



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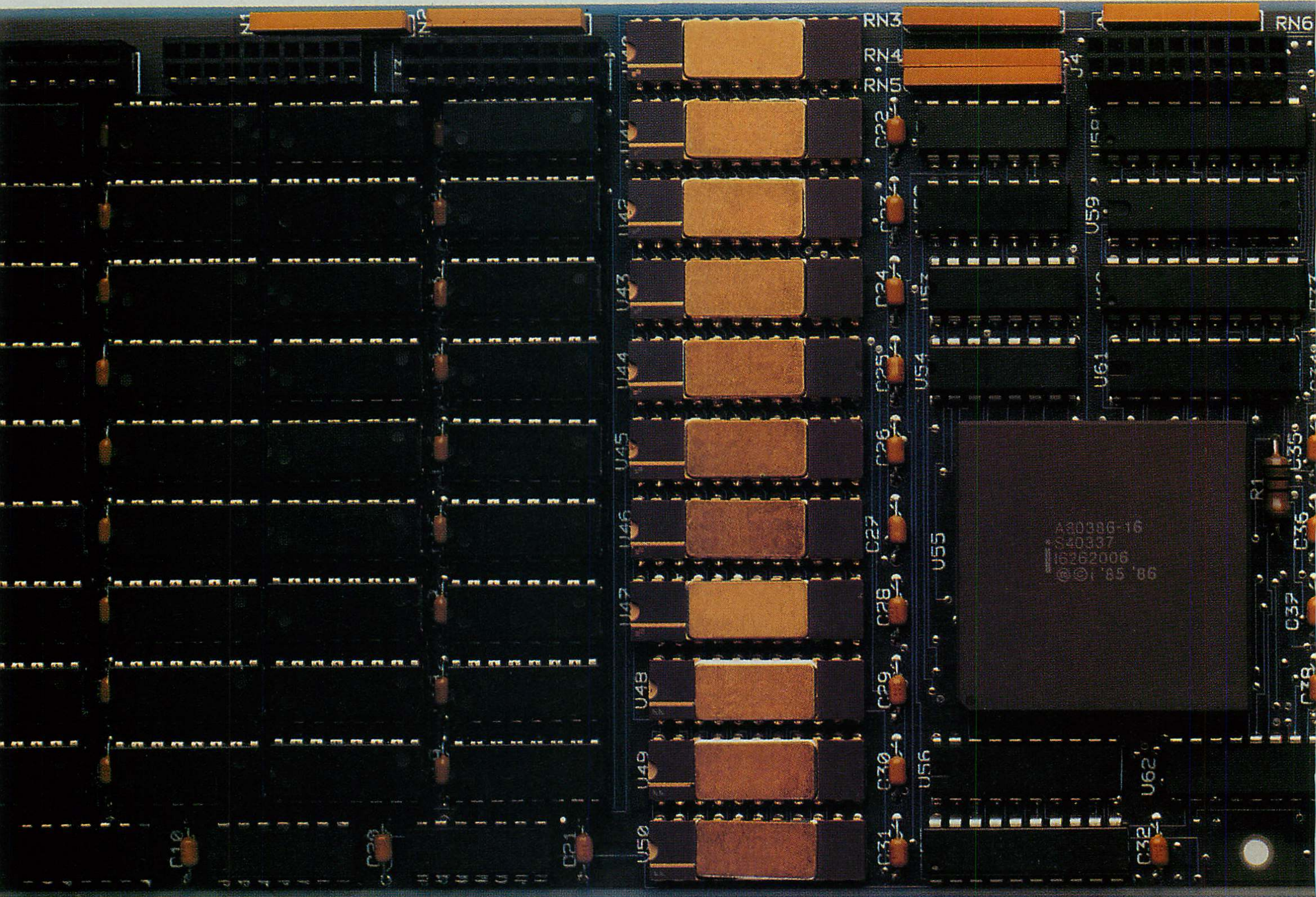
CIRCLE 161 ON READER SERVICE CARD

How to 386



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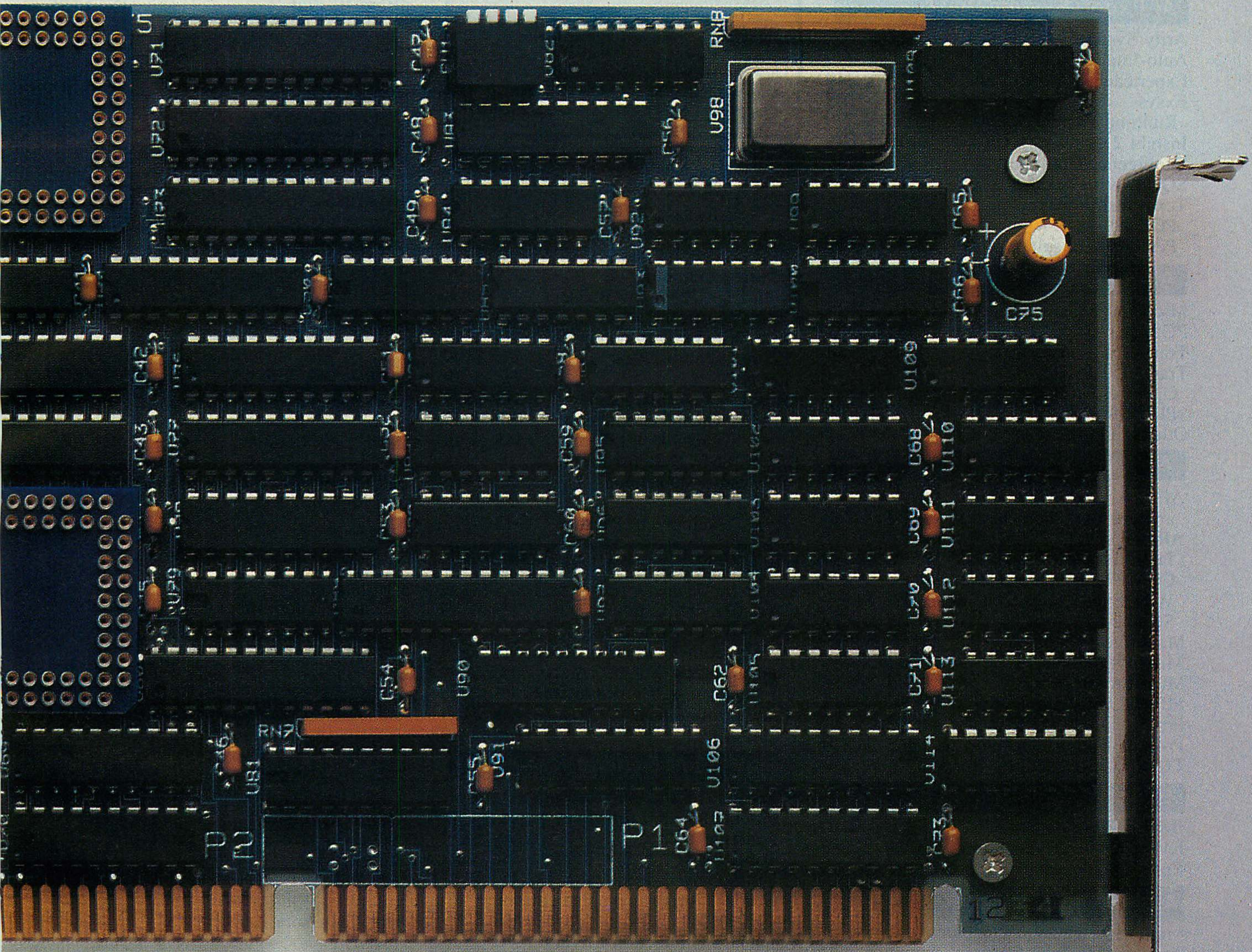

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Arity System - use with C	MS	$ 259
Auto-Intelligence	PC	$ 749
Experteach - Powerful, samples	PC	$ 349
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Runtime System	PC	$ 479
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PC Easy	PC	$ 439
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PC Scheme LISP - by TI	PC	$ 85
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FEATURES

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with Light Tools by Blaise	PC	$168
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C Libraries-Files

FILES: C Index by Trio - full B + Tree, vary length field, multi compiler		
/File is object only	MS	$ 89
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Informix 4GL-application builder	PC	$799
Informix SQL - ANSI standard	PC	$639
Opt Tech Sort - sort, merge	MS	$115
PANEL	MS	$215
Pfinish - by Phoenix	MS	$229
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CIRCLE NO. 162 ON READER SERVICE CARD

ALR ACCESS 386:

Poised for Tomorrow

Continuing a tradition, Advanced Logic Research brings up-to-date technology to affordable 386-based systems.

MICHAEL ABRASH and DAN ILLOWSKY

Advanced Logic Research (ALR), Inc., has built a product line of IBM-compatible computers that not only costs less, but also outperforms the originals from IBM. With the introduction of the Access 386, ALR has continued that tradition by bringing to market a reasonably priced, extremely powerful AT compatible built around the 32-bit Intel 80386 processor.

Three Access 386 models, differing in price and in hard disk, memory, and display adapter configuration are available. (See the accompanying sidebar for their features and prices.) The system reviewed in this article was the Access 386EC, with the following options: a 2MB, 32-bit memory expansion board, an enhanced keyboard, and a 10-MHz 80287 floating-point coprocessor. A 16-MHz 80387 will be available as soon as the 80387 is on the market.

The Access 386 sports a somewhat more stylish appearance than does the average AT, owing to horizontal openings in the grill across the front of the system unit rather than the usual vertical grid. Otherwise, the Access 386 system box is similar to that of the AT. The dimensions of the system unit are almost the same at 21.25 by 16.5 by 6.5 inches. Only the height is larger. The power-on and hard-disk-access indicator lights and the key lock are present in the same front panel locations as on the AT; the power switch is located in the same position, at the back of the right side of the system unit.

ALR has improved on the AT system unit by expanding the drive bay opening at the right of the front panel. Three half-height devices, rather than the standard two, can be accessed through the drive bay opening, so that a user can have a high-density drive, a 360KB drive, and a tape backup unit installed together. A second drive bay to the left of the first bay normally contains the hard disk, and it is not accessible from the outside.

The key lock works the same way as the AT key lock does. When the Access runs through its power-up tests, it checks to see whether the key lock is locked. If it is, a message is displayed to that effect, and the Access 386 waits until the F1 function key is pressed. This feature can save a user from thinking that the keyboard is defective when in fact it is only locked. However, if the

PHOTOGRAPH • MARC DAVID COHEN


ACCESS
386

PHOTO 1: *Original Keyboard Comparison*

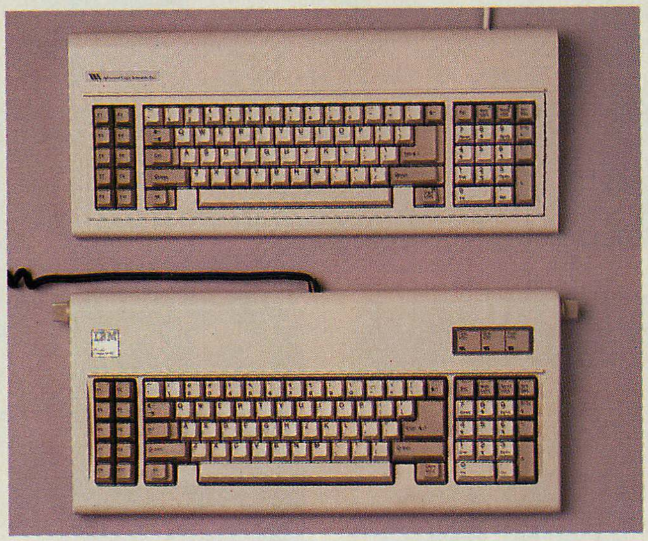


PHOTO 2: *Enhanced Keyboard Comparison*

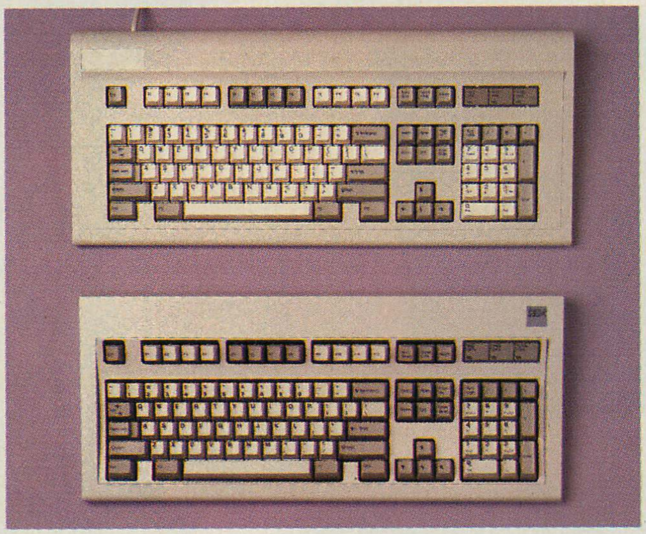
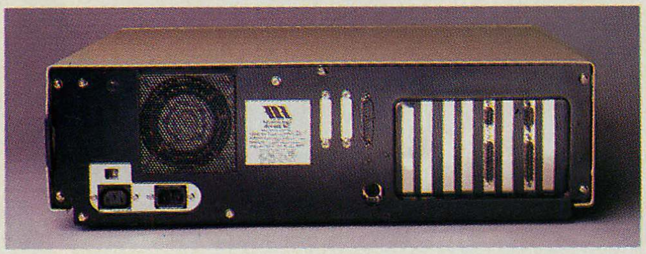


PHOTO 3: *Back Panel of System Unit*



Photos 1 and 2: The Access 386 keyboards are similar to their IBM counterparts (shown in the bottom of each photo.)

Photo 3: The rear panel shows the cutouts for the serial and parallel ports, between the fan and the expansion slots.

Photo 4: Inside the system unit, the hard disk is mounted in the left bay; the diskette drive is mounted in the right bay.

Photo 5: The 80386 is in the top right-hand corner. The 80287 option card is plugged into the 80387 socket.

Photo 6: Up to two 32-bit memory expansion boards can be installed for total of 4MB of 32-bit expansion memory.

PHOTO 4: *Inside the System Unit*

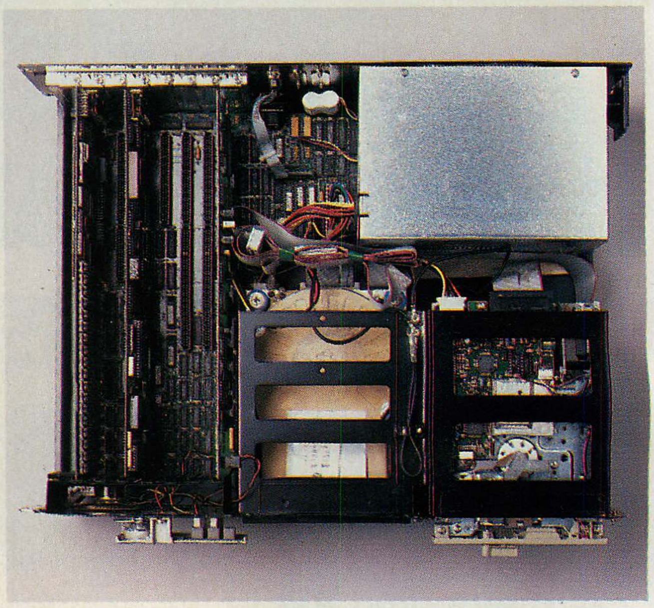


PHOTO 5: *System Motherboard*

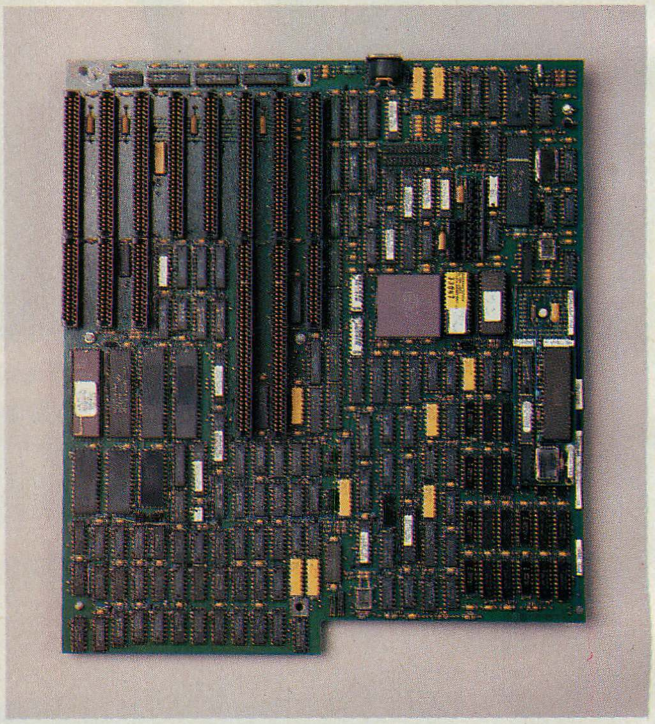
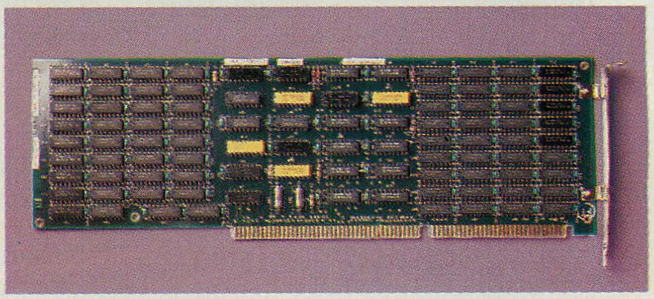


PHOTO 6: *2MB Expansion Board*



computer is operating unattended, it cannot automatically restart itself after a power interruption has occurred. This can be a problem in remote and network applications.

Two keyboards are available with the Access 386. One version is similar to IBM's original AT keyboard, and the other resembles the new enhanced AT keyboard. ALR now packages the enhanced keyboard with the Access 386, but the original version is available on request. Both keyboards were tested with the reviewed system and worked well. The original AT-style keyboard features green LED indicators on the NumLock, ScrollLock, and CapsLock keys rather than providing the separate indicator area used on the actual AT keyboard. Photo 1 compares the original IBM keyboard with ALR's version. This keyboard has a stiff feel, but, unlike all of the IBM keyboards, it does not provide tactile feedback. The keyboard cable is not long enough. The keyboard plugs into the back of the system unit, and the cable has to be stretched in order to position the keyboard in front of the system unit. Laptop typing, therefore, is not feasible.

The enhanced keyboard, shown in photo 2, is the preferable option. Like the keys on IBM's keyboards, the keys on ALR's enhanced keyboard have a maximum resistance point about halfway down, below which the key descends more easily. ALR's keyboard provides less tactile feedback than does IBM's, but in extended service it is still comfortable for a touch-typist. The cord on the enhanced keyboard is of more than adequate length. The enhanced keyboard that was reviewed displayed a minor peculiarity: when the system unit was powered on, the keypad sometimes came up in numeric mode and sometimes it came up in cursor mode. Likewise, on warm boots the keypad would come up in either mode, seemingly at random. The NumLock status indicator, however, always reported the state correctly, and otherwise the keypad operated in a normal fashion.

Certain keystrokes (for example, Alt-F10) are less convenient on the enhanced keyboard layout than they traditionally have been. While ALR's enhanced keyboard is generally a better keyboard than the standard AT-style version, prospective buyers of the Access 386 may want to consider how well the new layout will function with their favorite software.

The system unit generates a faint click with every keystroke. The clicking is so muted that it scarcely can be heard over the noise of the keys being pressed, and becomes apparent only when a key is held down and repeats. Lacking in the manual is the information that the click volume can be changed by pressing Ctrl-Alt-+ (the + on the numeric keypad). Eight volume levels are possible.

The reviewed system included ALR's enhanced graphics adapter (EGA) and color monitor. The ALR EGA is a full-length board built around the Chips and Technologies (C&T) chip set that has become the standard in the EGA-compatible market. For a review of C&T-based boards, see "Evaluating the EGA: The EGA Spectrum, Part 1 and Part 2," John T. Cockerham, October 1986, p. 80 and November 1986, p. 147.

ALR's EGA is fully compatible with the IBM EGA. Unlike some EGA-compatible boards, ALR's EGA does not support downward compatibility below the BIOS level with a color-graphics adapter (CGA) or any compatibility with the Hercules Graphics Card. It does not offer extended modes such as 640-by-480 pixel graphics or 132-column text. An extra feature provided by the ALR EGA is a built-in printer port, which is on the backplane connector of the EGA, just as it is in the monochrome adapter. This printer connector arrangement is convenient. To create the space that it occupies on the back panel connector of the EGA, ALR eliminated the feature connector jacks and moved the configuration switches to the middle of the EGA board, where they are inaccessible from outside the system unit.

The performance characteristics of ALR's color configuration are identical to that of the IBM EGA: resolutions of 640 by 350, 640 by 200, and 320 by 200 pixels, with up to 16 of a possible 64 colors available. The ALR EGA can drive a monochrome monitor, but because the EGA is bundled with a color monitor in the Access 386EC, it was evaluated as a color board only. The fonts used by the ALR EGA are markedly different from the IBM EGA fonts; they are more angular and feature fewer serifs, but are eminently readable.

The ALR EGA BIOS, from Phoenix Technologies, Ltd., is stored in a 16KB-

ALR ACCESS 386 VITAL STATISTICS

Since this article was written, ALR has reconfigured its product line. The display board and the 32-bit memory board are no longer bundled with the system, and an EGA board and monitor are offered as options. The monographics board and monitor are no longer available. The 1MB of memory is filled by the 16-bit Challenger multifunction board.

Access 386B: $3,990
512KB memory
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1.2MB diskette drive
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Diskette/hard-disk controller
Enhanced keyboard

Access 386-40: $5,699
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1.2MB diskette drive
Realtime clock
Enhanced keyboard
Diskette/hard-disk controller
40MB, 28-ms hard disk

Access 386-80: $6,569
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1.2MB diskette drive
Realtime clock
Enhanced keyboard
Diskette/hard-disk controller
80MB, 25-ms hard disk

Access 386-130: $8,490
1MB memory
Parallel and serial ports
1.2MB diskette drive
Realtime clock
Enhanced keyboard
Diskette/hard-disk controller
130MB, 20-ms hard disk

Memory capacity on system board
512KB

32-bit memory capacity of system
4.5MB now, 15.5MB to come

Expansion slots
32-bit: 2
16-bit: 4
8-bit: 2

Options available
360KB diskette drive: $199
2MB, 32-bit memory board: $1,695
10-MHz 80286 coprocessor kit: $795
ALR EGA board: $399
EGA color monitor: $699

by-8-bit ROM. The 8-bit data path to the ROM causes data and especially instruction fetches from the BIOS to occur much more slowly than fetches from motherboard memory—as much as eight times more slowly.

The color display is compatible with the IBM Enhanced Color Display supporting display modes of 320-by-200, 640-by-200, and 640-by-350 pixels and 64 colors. The monitor produces accurate colors and sharp, readable text on a dark background. The edges of the display area in the reviewed display are not quite linear (bowing out on the sides and in on the top and bottom) when measured against a straight edge, but the deviation is not obvious during actual use. The brightness, contrast, and on/off controls are thumbwheels on the right side of the monitor, where they are easily accessible without impinging on the available display area, as do controls located on the front panel of many EGA-compatible displays. Two lights indicate whether the power is on and whether the monitor is in 200- or 350-scan-line mode.

A monochrome display system was not included with the reviewed system. The Access 386EM model, however, features a monochrome display system, including Hercules-compatible monographics and a monochrome monitor. The base Access 386 system, the 386B, comes without a display system.

The monitor rests on an adjustable pedestal base, which allows the user to change the angle, but which also makes the monitor sit a bit too high for comfortable viewing when placed atop the system unit. The ideal configuration for the Access 386EC is with the monitor sitting directly on the desktop, with the system unit off to one side or under the desk. The monitor cable is approximately three feet long, making it possible to move the color display away from the system unit.

The diskette drive included with all Access 386 models is a standard AT-style 1.2MB drive. The drive is spring-loaded and ejects diskettes about an inch when the latch is opened.

AVAILABLE PORTS

A serial port and a parallel port are built into the motherboard. Both can be used via short cables terminating in standard PC-style, 25-pin, D-shell connectors in special cutouts on the back panel of the system unit (see photo 3). The cutouts are located between the power supply fan and the expansion slots. The serial port can be configured as COM1 or COM2 or disabled. The parallel port can be configured as LPT1 or LPT2 or disabled. All of the Access 386 models have these ports built in. The Access models 386EC and 386EM include the ALR Challenger multifunction board, which adds a serial port and a parallel port, as well as up to 2MB of 16-bit memory. These additional ports can be configured in the same way. The display boards included in the Access 386EC and 386EM models also include parallel ports that can be configured as LPT1 or disabled.

In the reviewed Access 386, the motherboard parallel port was disabled and left unconnected, and the parallel ports on the ALR EGA and the Challenger board occupied the two parallel port locations available to non-monochrome-adapter parallel ports. The motherboard parallel port was thus redundant. In the Access 386EM, however, the parallel port on the monochrome display board is at the location reserved for monochrome-adapter parallel ports; with the proper cable to hook up the motherboard parallel port, it should be possible to have three rather than the

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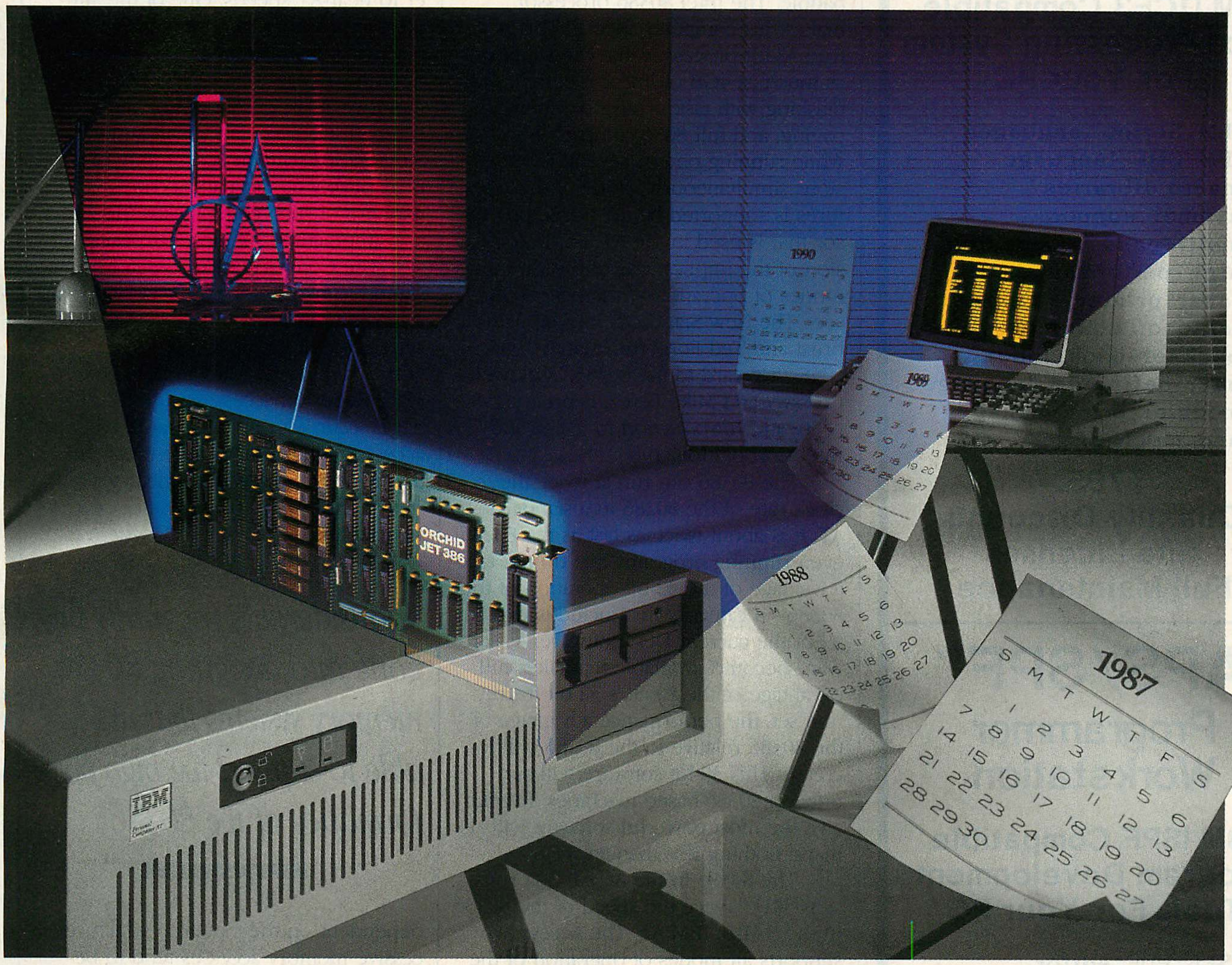

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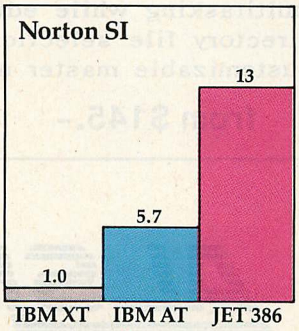

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advertised two parallel ports available in the Access 386EM.

ALR's Access 386 is more than just a well-designed, solidly built AT compatible. The Intel 80386 processor makes this computer special. This is a true 32-bit processor that can support as much as 4GB of linear memory, multitasking with task protection, memory paging, and full 8086 compatibility while running one or several DOS sessions simultaneously. None of these features is supported by the 80286 processor that is used in the AT. For a discussion of the implications of the various modes of operation of the new 80386, see "The New Standard," Steven Armbrust and Ted Forgeron, March 1987, p. 48; "Upward to the 80386," Caldwell Crosswy and Mike Perez, February 1987, p. 50; and *Introduction to the 80386*, Intel Corporation, 1986.

The 80386 can run at twice the clock rate of the 80286 in a standard AT; it is about twice as fast as the 80286, even running programs that do not take advantage of the 32-bit operation of the 80386—a category that includes virtually all of the current DOS software. As software becomes available that takes full advantage of the 80386's 32-bit instruction set, the performance advantage of the 80386 relative to the 80286 will increase. This 32-bit software will run only on 80386-based machines. Eventually, the most powerful software will demand nothing less than an 80386.

The 80386 in the Access 386 runs at 16 MHz, twice the speed of the 80286 in the 8-MHz IBM AT. The Access 386 supports all modes of operation of the 80386: real mode, protected mode, and virtual-8086 mode. All of the currently available 80386-based computers feature 16-MHz operation. Significant performance differences between 80386-based computers will result primarily from memory system architecture. While the 80386 itself is an extremely fast processor, inexpensive memory in a standard configuration cannot supply information as fast as the 80386 demands it. Consequently, considerable ingenuity has gone into designing 80386 memory systems, and the design of an affordable memory system that can support the high performance of the 80386 is a difficult task that can be approached in a number of ways.

APPROACHES TO MEMORY

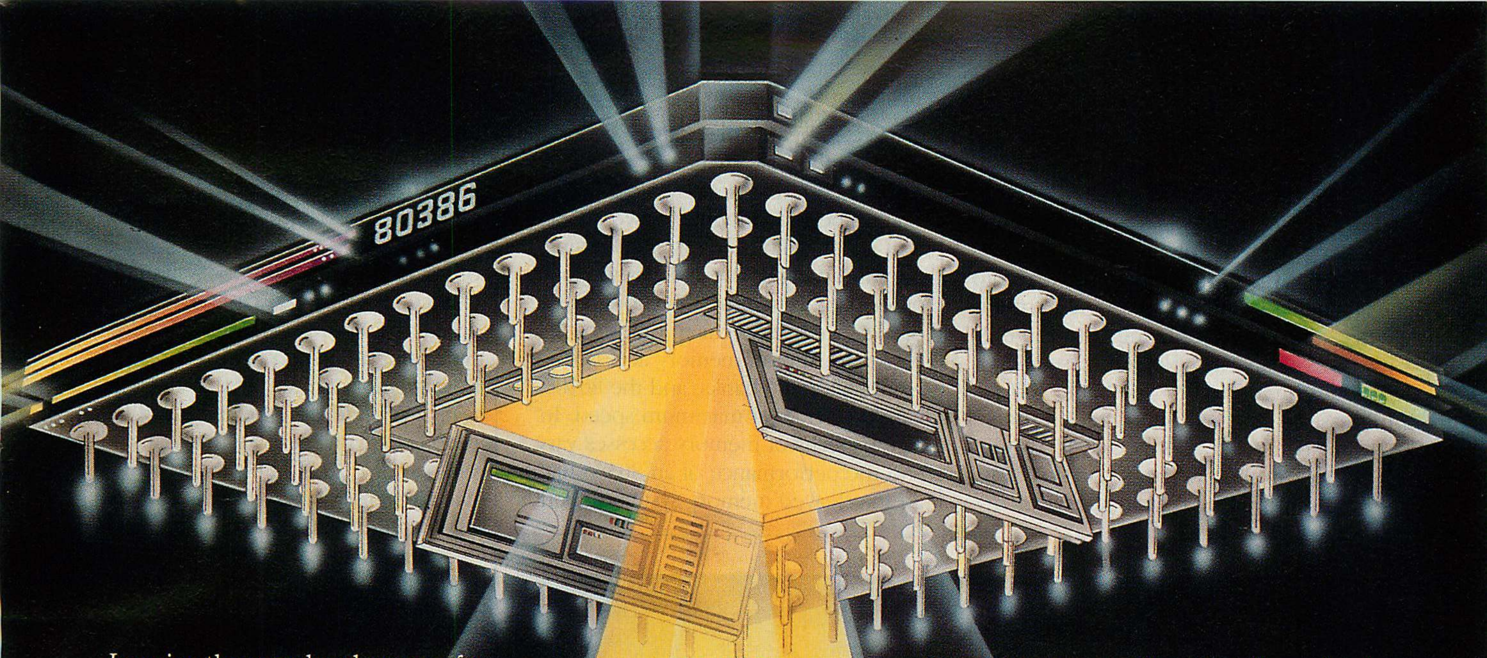
A brief summary of memory architecture options will help to place the Access 386 in the spectrum of 80386 computers. An 80386-based computer could be built with readily available, relatively inexpensive DRAM chips, as is done in the AT. This approach, however, results in several wait states on every memory access and effectively slows the computer to near-AT speeds. One of the simplest approaches to developing a high-performance 80386 memory system is building a system in which all of the memory is fast enough to let the 80386 run with no wait states. This requires SRAM chips with an access time of approximately 60 ns (nanoseconds); the expense of such chips makes this option impractical for most purposes.

The Compaq Deskpro 386 is designed to use an 80386 memory system static-column RAM. In this architecture, system memory consists of a number of fairly small pages (2KB in the Deskpro 386). Repeated accesses within a single page occur with no wait states, while an access that falls in a different page from the previous access does incur wait states. The overall performance of a static-column RAM memory system is

Considerable ingenuity has gone into designing 80386 memory systems that are able to support the high performance of the 80386.

dependent on the extent to which successive memory accesses tend to be local within the same page.

Another approach is the use of a memory cache. In this case, a relatively small (usually 64KB or less), fast SRAM memory is used to store a copy of the most recently accessed locations in normal memory. Because most accesses (generally more than 90 percent) occur to the fast cache memory, performance improves dramatically. The extent of the improvement is dependent on the *hit rate* of the cache, the frequency with which accessed memory locations tend to be in the cache. Memory caching becomes more important as processor speed increases. A 24-MHz 80386 without a cache would likely be severely bound by memory speed because any type of memory (such as the static-column RAM used in the Deskpro 386) that is affordable enough to be used in megabyte quantities would not be able to run as fast as the 80386 and would greatly slow the processor by inserting many wait states. It is not clear, how-



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ever, that the additional cost of cache logic and memory is justified in a 16-MHz 80386 computer.

The Access 386 uses memory interleaving for building an 80386 memory system. System memory is divided into two banks, with sequential 32-bit memory addresses alternating between the banks. As an example, addresses 0-3 would be located in one bank, addresses 4-7 would be located in the other bank, and addresses 8-11 would be back in the first bank. DRAM chips require a waiting period after a memory access before they can be accessed again; in the case of the 120-ns DRAM chips used in the Access 386, this extra waiting period amounts to two 80386 wait states. With memory interleaving, one of the banks can recover while the other bank is accessed—as long as successive accesses occur to different banks. Ideally, all memory accesses would alternate banks, and the 80386 would operate at maximum speed. In fact, patterns of memory accesses vary and the performance of an 80386 with an interleaved memory system depends on the tendency of the application to alternate between banks.

The 80386 can perform address pipelining, placing memory addresses on the address bus one cycle early in order to give the memory system a chance to get started early with the next access. If idle bus cycles occur, address pipelining must be restarted on the next memory access, at a cost of one wait state. Address pipelining can be used only with memory that takes advantage of it. The 32-bit memory in the Access 386 has been designed to take advantage of this feature.

The Access 386 combines memory interleaving and address pipelining in an affordable system. The 512KB of motherboard memory is divided into two 256KB interleaved banks and supports address pipelining. These techniques are used with 120-ns DRAM chips, which would provide only about half the performance required to allow the 16-MHz 80386 in the Access 386 to run without wait states.

Code that is register-intensive should allow the Access 386 to run at almost top speed, because most memory accesses will be instruction prefetches, which are 32-bit fetches to alternating banks, except when branching. As a result, although the 80386 performs memory accesses much faster than does the 8088, memory access is still a bottleneck, and astute register use remains a key to high-performance code. Most code does not access memory sequentially, however, because instruction prefetching and operand accesses are mixed together; there is no reason to expect a bank-alternating relationship between the two types of memory access.

Another consideration is the memory access characteristics of code written for 8088s and 80286s, which does not access memory in 32-bit units. As an example, REP STOSB runs more slowly on the Access 386 than does REP STOSD (which stores 32 bits at a time), because REP STOSB accesses the same bank four times in a row and then accesses the other bank four times in a row. It therefore is able to gain the advantages of interleaving only once out of four memory accesses.

When running normal software, the memory system in the Access 386 often inserts wait states because of failure to alternate banks; indeed, the performance tests examined later in this article indicate that two to three wait states are inserted on average. The insertion of wait states in the Access 386 does have one advantage. If idle bus cycles

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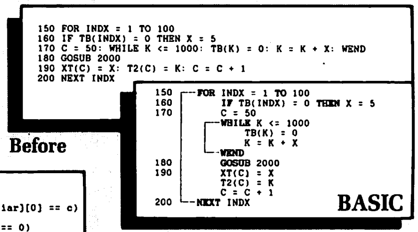

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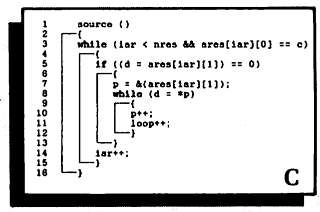

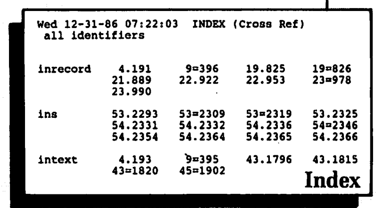

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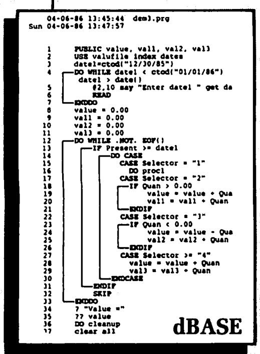

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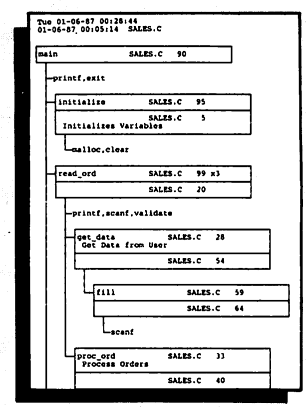

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occur, address pipelining is turned off. The Access 386 is relatively memory-bound because of memory wait states, and as a result the memory bus is active almost all of the time. Idle cycles are rare, so the one-wait-state penalty that occurs when address pipelining is turned off is not invoked very often.

The memory system in the Access 386 is considerably faster than that of an AT, but slower than a no-wait-state architecture would be. Further evaluation for the performance-oriented user can be made by testing specific applications of interest on the Access 386.

The motherboard provides only 512KB of 32-bit memory rather than the expected 640KB. Additional interleaved, address-pipelined 32-bit memory can be added in the two 32-bit expansion slots. The address decoding logic for these slots is built into the motherboard, making them extensions of the motherboard memory system and not general-purpose 32-bit expansion slots.

Currently, 2MB of memory can be installed in each slot; 8MB boards will be available soon, bringing the maximum total to 15MB of 32-bit expansion memory. Memory cannot be added beyond address 0FFFFFFH: although the 80386 is capable of addressing up to 4GB of physical memory, the limit in the Access 80386 is slightly less than 16MB. The virtual memory features of the 80386, however, can be used to make the address space seem as large as the available disk space.

The 128KB area of memory from the 512KB boundary to the 640KB boundary is not supplied on the ALR's motherboard. This area of memory can be filled out with the 16-bit memory on

The Access 386 memory system is a fairly high-performance, low-cost solution to keeping up with the 80386 processor.

the Challenger board with the associated reduction in performance, or the 32-bit memory board can be used with the Quarterdeck Expanded Memory Manager (QEMM) to backfill the memory using its EMS emulator feature. Quarterdeck Office Systems' DESQview contains QEMM and is supplied with the Access 386 setup/utilities diskette.

While 16-bit memory works in the Access 386, it works much more slowly than does 32-bit memory. Two accesses to 16-bit memory are required to fetch 32 bits, while only a single access is needed to fetch 32 bits from 32-bit memory. Existing DOS software is written for the 16-bit 8088 and 80286 processors. Code written specifically for the 80386 accesses memory in units of 32 bits. If this memory is 16-bits wide, two memory accesses are required to obtain a single 32-bit doubleword, causing the code to run up to two times slower than optimum.

Another reason for the slower performance of 16-bit memory is that 16- and 8-bit boards are run at 8 MHz in the Access 386. This lower speed is necessary because these boards are designed for 8-MHz ATs and will not operate properly at 16 MHz, but it also means that 16-bit memory runs at half the speed of 32-bit memory. Some expansion boards, such as the Intel Above Board and the Cheetah memory card, do not operate reliably above the AT's 8-MHz standard. See "PC's Limited 286^{12}" (Steven Armbrust and Ted Forgeron, February 1987, p. 94) for a discussion of this limitation of a 12-MHz bus.

AT-style 16-bit memory is not interleaved and does not support address pipelining. The net effect of these factors is that accesses to 16-bit memory can take from 33 percent to more than 500 percent as long as the same access performed to 32-bit memory.

A similar slowing occurs while accessing ROM in the Access 386, such as the 16-bit ROM BIOS. An 8-bit ROM, like the EGA BIOS, will be even slower. In the worst case, a 32-bit read from 8-bit memory can take more than 10 times as long as a 32-bit read from 32-bit memory. Other 80386-based computers have addressed this by copying ROM chips into 32-bit RAM; the Access 386 does not do this. ROM performance is rarely crucial, because time-critical applications tend to bypass the ROM and go directly to the hardware. Also, because ROM operations generally are interleaved with the operation of a program running in RAM, the overall high performance of the Access 386 tends to mask the slow ROM operation.

In summary, the Access 386 memory system is a fairly high-performance, low-cost solution to building memory that can keep up with the 80386. This is balanced with the need to maintain an AT-compatible bus that will run all add-in boards reliably.

After memory performance, disk performance is perhaps the most im-

portant factor to consider when evaluating the speed of an 80386-based computer. The 42MB hard disk used in the Access models 386EM and 386EC has a 28-ms (millisecond) access time; this is considerably faster than the hard disk used in the IBM AT. However, it is comparable to the Compaq's 40MB disk access time of 25 ms.

The Access 386 offers a slowdown mode, also known as *deturbo mode*, in which the Access 386 runs at approximately the speed of an 8-MHz AT. Deturbo mode operates by inserting processor hold states, which are superior to wait states for slowing the processor because they do not affect the bandwidth of the system bus for DMA operations. This mode is useful for running copy-protected software or for slowing down programs that are too fast to use at normal Access 386 speeds. It is not slow enough to allow software designed for the PC, most notably games, to run at normal speed. Unfortunately, few users may learn the deturbo mode, since it is not referenced in the manual. Deturbo mode is selected via Ctrl-Alt-1, and normal mode is selected via Ctrl-Alt-2. The system always is set back to normal speed by a warm boot.

A LOOK INSIDE

No user installation is required for the Access 386 as it is shipped from the factory. However, the user who wants to install options and accessories in the system unit will find the process the same as that used with the AT because the physical layouts are similar. Five Phillips-head screws on the back panel hold the cover on the system unit. Although other Phillips-head screws are nearby, the screws that hold the cover can be easily identified. Once the screws are removed, the cover can be slid off the system unit over the front panel, as with the AT.

The inside of the system unit is shown in photo 4, and the motherboard itself in photo 5. The eight expansion slots on the motherboard are located as they would be in an AT, and expansion boards are installed and anchored in the familiar AT fashion. Some effort was required to install boards, as the back panel of the system unit did not align perfectly with the ends of the expansion boards. The two 32-bit expansion sockets are keyed so that 16-bit boards cannot be installed into these slots, although 8-bit boards can be used.

Removal and installation of the motherboard is not particularly difficult. After removing all of the expansion boards and disconnecting the power leads and several other wires, then the motherboard is extracted by removing two screws, sliding the whole board to the left, and lifting up. The disk drives do not have to be removed.

Disk drives slide into the two drive bays from the front and are anchored at either side. The left bay can contain one full-height or two half-height hard disks. The small panel that contains the key lock and the power indicator light must be removed in order to get a drive into or out of the top slot in the drive bay. The right drive bay has slots for three half-height drives, but there is only room for two diskette drives and a shorter drive, such as a tape backup unit. All of the drives installed in the right drive bay can be accessed from outside the system unit when the system is closed up. In the tested system, the half-height 42MB hard disk occupied the left bay, while the 1.2MB diskette drive occupied the topmost of the three slots in the right bay.

The disk controller supports up to two hard disks and two diskette drives. A second diskette drive can be daisy-chained to the same connector as is the first diskette drive. A second hard disk can daisy-chain to one of the hard disk connectors, but it requires one additional cable not supplied with the Access 386. The standard hard disk that is shipped with Access models 386EM and 386EC is a 42MB, 28-ms access time unit; an 80MB, 28-ms hard disk is available as an option.

Two of the three ribbon cables from the controller to the drives in the reviewed unit were not keyed to ensure installation with pin 1 of the connector attached to pin 1 of the cable. All three cables did have markings indicating the side to be connected to pin 1, but novice users may not know what those markings mean.

Only 32MB out of the 42MB disk space in the tested system was usable, because a special driver is required in order to get DOS to support disks larger than 32MB, and ALR does not ship such a driver with the Access 386. In "Breaking the 32MB Barrier," (May 1986, p. 94) Thomas V. Hoffmann reviewed a method used to configure a large hard disk into a large single volume or two separate volumes. ALR is apparently relying on dealers to configure the Access 386 with third-party software. If necessary, however, ALR will recommend an appropriate driver to owners of the Access 386 who can then purchase and install it.

Third-party hard disks are supported by the ROM BIOS of the Access

TABLE 1: *Disk Drives Supported*

DRIVE TYPE	NO. OF CYLINDERS	NO. OF HEADS	CAPACITY (MB)	LANDING ZONE CYLINDER	PRECOMPENSATION CYLINDER
1	306	4	10.1	305	128
2	615	4	20.4	615	300
3	615	6	30.6	615	300
4	940	8	62.4	940	512
5	940	6	46.8	940	512
6	615	4	20.4	615	−1[a]
7	462	8	30.6	511	256
8	733	5	30.4	733	−1
9	900	15	112.0	901	−1
10	820	3	20.4	820	−1
11	855	5	35.4	855	−1
12	855	7	49.6	855	−1
13	306	8	20.3	319	128
14	733	7	42.5	733	−1
16	612	4	20.3	663	0
17	977	5	40.5	977	300
18	977	7	56.7	977	−1
19	1,024	7	59.5	1,023	512
20	733	5	30.4	732	300
21	733	7	42.5	732	300
22	733	5	30.4	733	300
23	306	4	10.1	336	0
25	615	4	20.4	615	0
26	1,024	4	34.0	1,023	−1
27	1,024	5	42.5	1,023	−1
28	1,024	8	68.0	1,023	−1
29	512	8	34.0	512	256
35	1,024	9	76.5	1,024	1,024
36	1,024	5	42.5	1,024	512
37	830	10	68.8	830	−1
38	823	10	68.3	824	256
39	615	4	20.4	664	128
40	615	8	40.8	664	128
41	917	15	114.1	918	−1
42	1,023	15	127.3	1,024	−1
43	823	10	68.3	823	512
44	820	6	40.8	820	−1
45	1,024	8	68.0	1,024	−1
46	925	9	69.1	925	−1
47	699	7	40.6	700	256

[a] *The −1 values mean that no write precompensation is used for the drive.*

The Access 386 supports 41 hard-disk types. This allows ample flexibility in selecting an alternative hard disk. Several of the AT disk types do not appear in this list.

386. The SETUP program lists 41 disk types that are supported (see table 1). The disk types supported by the AT are not supported by the Access 386 with the same type numbers; in fact, several of the AT disk types do not appear in the Access 386 SETUP program's list of disk types at all.

The power supply includes three cables for powering peripherals. Two of the cables have two connectors and the other has one, indicating that a total of five peripheral devices can be connected, although their combined power demands must be within the power supply's capacity of 200 watts.

While the 80386, ROM BIOS, and 80387 sockets are all fully visible from above, they are in a hard-to-reach area between the left drive bay, the disk controller board, and the power supply. Realistically, at the least the disk controller board has to be removed in order to work easily with any of these chips.

The 16-MHz Intel 80386 is a large square chip mounted in a socket at the center-right of the motherboard, just to the back of the left drive bay (see photo 5). The ROM BIOS chips are socketed to the right of the 80386, and similarly are not obscured by any equipment.

The 80387 socket is to the right of the ROM BIOS between the left drive bay and the power supply; while the socket itself is not obscured, it is difficult to reach without removing the motherboard. The reviewed system came with a socketed 10-MHz Intel 80287 numeric coprocessor option, a small adapter board that plugs into the 80387 socket. The 80287 option card extends well under the drive bay, and the motherboard had to be taken out in order to remove the 80287 card. It will be possible to use a 16-MHz 80387 in this socket as soon as that chip becomes available.

To this point, the configuration for the Access 386 has been very similar to that for the AT, except for the two 32-bit slots. Unlike the AT, the motherboard on the Access 386 is lacking switch blocks; this makes configuration more difficult. More than a dozen jumpers are used to set the serial and parallel port operation, indicate whether a numeric coprocessor is installed, select a color or monochrome primary display, indicate whether and how many 32-bit memory expansion boards are installed, and perform a number of more esoteric functions.

Unfortunately, these jumpers are scattered around the motherboard, many of them are in hard-to-reach locations, and often more than one is required to configure a single feature of the Access 386. For example, the three jumpers that indicate what 32-bit memory boards are installed are located between the disk controller and the left drive bay and are not accessible (or even visible) unless the disk controller is removed. A pair of needlenose pliers is required to change the jumpers, and the proximity of several jumper pins makes the task difficult. The jumpers could pose a problem to users accustomed to switch blocks that can be toggled with a ballpoint pen.

The Access 386 offers eight expansion slots: two 8-bit slots, four 16-bit

slots, and two 32-bit slots. The 32-bit slots are the second and third slots from the right in photo 4. The rightmost slot is a 16-bit slot that is used for the disk controller; this positioning means that the disk cables do not have to traverse other expansion boards. Each 32-bit slot consists of two connectors. One of these connectors is a standard 8-bit connector, into which 8-bit boards can be plugged. The second connector is keyed in the middle; this keying means that 16-bit boards cannot be plugged into 32-bit slots. However, 8-bit boards can be plugged into any of the eight expansion slots, so long as the skirt on the board does not hit the extended 16- or 32-bit connector; as in the AT, the two 8-bit slots are the only slots in which 8-bit boards with such skirts can be installed.

As discussed above, 32-bit memory is essential to high performance when running software that takes full advantage of the 80386. The 32-bit slots are actually extensions of the motherboard memory system and can be used only for memory boards. Currently, the only available expansion boards that can take advantage of the 32-bit slots in the Access 386 motherboard are 2MB boards manufactured by Intel (see photo 6). Two of these boards can be installed at one time, for a total of 4MB of 32-bit expansion memory. Neither of the 32-bit slots is occupied normally because the Access 386 is delivered with 16-bit expansion memory only. Optional 32-bit memory boards are, however, available from ALR.

Of the remaining five slots, one 8-bit slot is occupied by the video adapter and one 16-bit slot by a multifunction memory board. (The base model, the Access 386B, does not come with any expansion board other than the disk controller.) In the Access 386EM, the video adapter is a Hercules-compatible monographics board and the multifunction board is ALR's Challenger board, with a serial port, a parallel port, and 512KB of 16-bit memory installed, expandable to 2MB. The reviewed system, the Access 386EC, comes with an IBM EGA-compatible video adapter and a Challenger board with a full 2MB of 16-bit memory installed.

The motherboard contains 512KB of memory, consisting of two interleaved 256KB banks of eight 64KB-by-4, 120-ns DRAM chips each. Eight 64KB-by-1, 120-ns DRAM chips are used for parity bits. No memory expansion is possible on the motherboard. The Challenger board is split addressed to top off DOS with 16-bit memory and to add extended memory starting at 1MB. This prevents the use of 32-bit memory expansion boards, which must start at 1MB and would conflict with the Challenger memory. ALR has solved this problem by making available a new memory decode PROM for the Challenger board that allows it to top off DOS, and then address the remaining 16-bit memory above the 32-bit memory.

The motherboard in the Access 386 is the iSBC 386AT, designed and manufactured by Intel. The reviewed model came with version 3.03 of the Phoenix ROM BIOS. This version of the motherboard corrects several of the problems that were encountered by motherboards with version 3.0 and earlier of the BIOS. One of these problems was the failure to support the EGA's vertical interrupt properly, and another was an inability to get the 80287 to pass IBM AT Advanced Diagnostics. The motherboard had a number of soldered wires running across it; these are probably recent fixes, indicating that the last bugs have only recently been ironed out of the motherboard.

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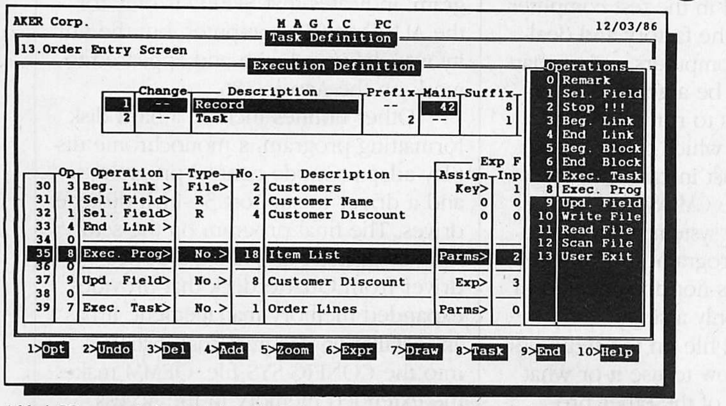

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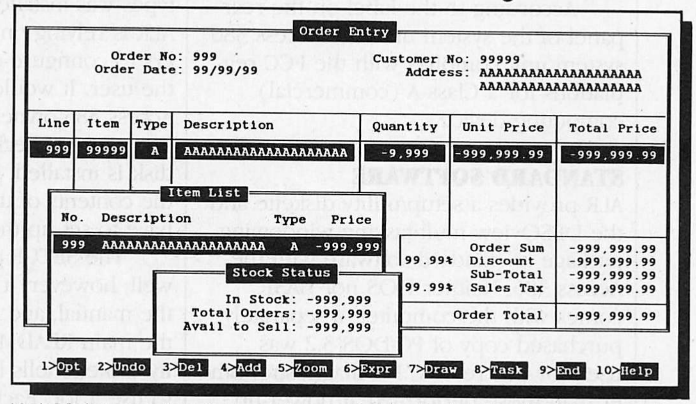

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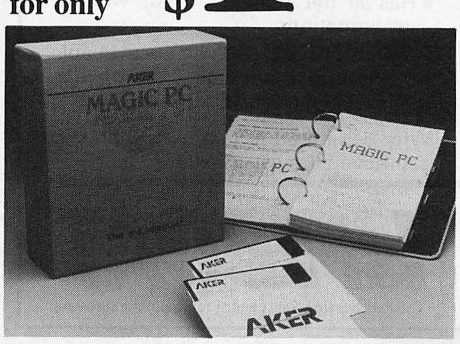

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When comparing 386-based computers, it is wise to check the motherboard. Other computers built around the iSBC 386AT are likely to share many of the characteristics of the Access 386, in which case other considerations such as hard disks, bundled software, and price will take on added importance.

According to the label on the rear panel of the system unit, the Access 386 system unit complies with the FCC regulations for a Class A (commercial) computing device.

STANDARD SOFTWARE

ALR provides a setup/utility diskette and the DESQview multitasking windowing package as standard software with the Access 386. Neither DOS nor BASIC comes with the computer; a separately purchased copy of PC-DOS 3.2 was used for this review. No diagnostics other than those performed at power-up are provided, although IBM's Advanced Diagnostics runs on the Access 386 and can be used if necessary.

The setup/utility diskette contains Phoenix's SETUP program, used to set the contents of the battery-backed CMOS RAM that stores the computer's configuration. Configuration information is stored in battery-backed CMOS RAM present on an MC146818 realtime clock chip, just as in the AT. This program is similar to the SETUP program on IBM's AT Advanced Diagnostics disk, with the useful addition of a table of the characteristics of 41 hard-disk types supported by the Access 386. Neither the documentation nor the hard-disk housing indicates which of the 41 drive types was installed in the test computer. ALR is relying on the factory and dealers to configure computers, rather than the user. It would be a good idea for Access 386 owners to run the SETUP program to check which type of hard disk is installed, just in case they lose the contents of the CMOS RAM and have to set up the system themselves.

The SETUP program itself works well; however, it is not documented in the manual, and only a single entry in the main README file on the setup/utility diskette tells how to use it or what to use it for. Each of the other programs on the setup/utilities diskette has at least a short README file; this is better than nothing, but is no substitute for good coverage in the manual. In addition, the README files are incomplete and full of typographical errors.

ALR provides a SPEED utility for selecting between normal and deturbo operation, as an alternative to Ctrl-Alt-2 and Ctrl-Alt-1. When run, the program prompts the user for the new speed. This utility would be more useful if it accepted a command line parameter for the speed selection, allowing it to be used in batch files without requiring the user to type a response. The file README for the SPEED utility, which is the only documentation for the program, indicates that SPEED is only for the ALR Dart 012 computer, but the utility was delivered with and appeared to work on the Access 386.

Other utilities include a hard disk formatting program, a monochrome display adapter mode control program, and a driver to support 3½-inch diskette drives. The final program on the setup/utilities diskette is QEMM, a device driver from Quarterdeck that provides expanded memory management. It has an installation program that installs it into the CONFIG.SYS file. QEMM makes the extended memory in the Access 386 (memory above 1MB, which is not used by DOS) appear to be expanded memory of the Lotus/Intel/Microsoft (LIM) specification to DOS programs that can take advantage of LIM expanded memory, such as Lotus 1-2-3, Living Videotext's Ready!, and Intel's QUIKMEM2 RAM disk.

The virtual-8086 mode of the 386 makes it possible to make extended memory work like expanded memory. QEMM operates by modifying the page tables of the 386 to map the desired areas of extended memory into the page frame through which expanded memory is accessed. It puts the 386 into virtual-8086 mode because such mapping is not possible in real mode (the power-up state of the 386, in which the 386 acts as a fast 8086). Normally, virtual-8086 mode is used to run multiple copies of DOS simultaneously, with each copy thinking it has an 8086 computer all to itself. In the case of QEMM, however, virtual-8086 mode is used to run just one copy of DOS, just as in real mode, the difference is that extended memory is mapped into the expanded memory page frame.

The manner in which QEMM works is transparent to DOS and applications that used expanded memory. Virtual-8086 mode does have one slight drawback, however; all interrupts in virtual-8086 mode cause a trap to QEMM, slowing performance slightly. The actual performance loss will vary from one application to another.

One benefit of QEMM is that it allows programs that use expanded memory to run without requiring a separate expanded memory board. Few programs can use the extended memory

above 1MB directly; many more can use expanded memory. QEMM makes a great deal of expanded memory available at no cost because the reviewed configuration of the Access 386 comes with nearly 2MB of extended memory.

The second benefit of QEMM is its synergy with DESQview, which was written originally for the 8086. While DESQview works well on 8086s, programs running on the 8086 cannot be protected from each other or allowed true multitasking in which each program has a full 640KB and a separate screen available. The virtual-8086 mode of the 386 makes all of the above possible, and when DESQview is run with QEMM loaded, virtual-8086 multitasking is supported. Installed memory permitting, as many as nine virtual PCs can be run simultaneously. DESQview worked well in the *PC Tech Journal* tests, although it was hard to be certain exactly how DESQview was taking advantage of the 80386 because the copy of DESQview that accompanied the Access 386 included no documentation whatsoever pertaining to operation with QEMM.

PERFORMANCE TESTING

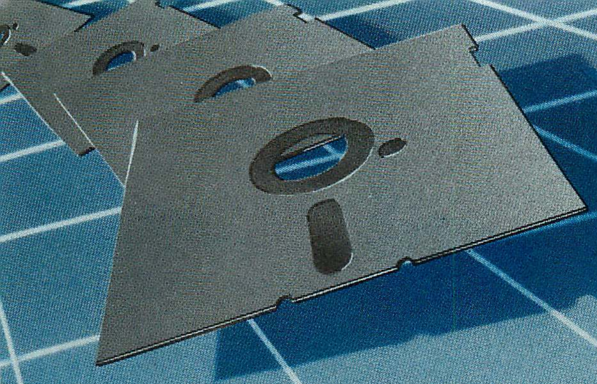
As is standard in the *PC Tech Journal* Compatibility and Performance series, the Access 386 underwent two types of tests. First, commonly used hardware and software products were installed to test the AT compatibility of the Access 386. Next, the *PC Tech Journal* AT Evaluation Suite of compatibility and performance tests was run. (See "Updating the Evaluation Suite," Ted Forgeron, Paul Pierce, and Steven Armbrust, March 1987, p. 70.) The results were compared to the 8-MHz IBM AT and the Compaq Deskpro 386. All testing was performed on an Access 386EC, with an enhanced keyboard and a 10-MHz 80287 numeric coprocessor option.

The hardware products were a 10-MHz 80287 numeric coprocessor chip, an Intel Above Board with 4MB of memory, Microsoft serial and bus mice, a Cheetah zero-wait-state 1.5MB memory board, an IBM Game Adapter, and a Hayes Smartmodem 1200B internal modem. The EGA was also tested, but the tests were run using ALR's EGA, not the IBM board.

Two hardware products failed to run properly on the Access 386: Cheetah zero-wait-state memory and the Microsoft bus mouse. The Access 386 would not even boot when a Cheetah board configured for zero-wait-state operation was installed. When the Cheetah board was configured for one-wait-state operation, however, both the board and the Access 386 functioned normally.

The Microsoft bus mouse did not work when used with Microsoft Windows. The mode of failure was erratic; often Windows would fail to start up, and even when it did, the display was generally garbled and the mouse was always nonfunctional. This was true with the interrupt select jumper on the bus mouse board set in all four possible positions. The bus mouse did work with Microsoft Word and with other software, and Microsoft Windows worked well with the Microsoft serial mouse. The problem seems to be a specific interaction among Windows, the bus mouse, and the Access 386.

While the IBM Game Adapter functioned properly in the Access 386, software that relied on timing loops to read the position of the joystick attached to the Game Adapter did not work well. Even software that automatically calibrated the joystick before using it sometimes concluded that the joystick was broken because the Access 386 ran so rapidly that the joystick counts seemed to be out of any reasonable range. Software that uses the system timer to pro-



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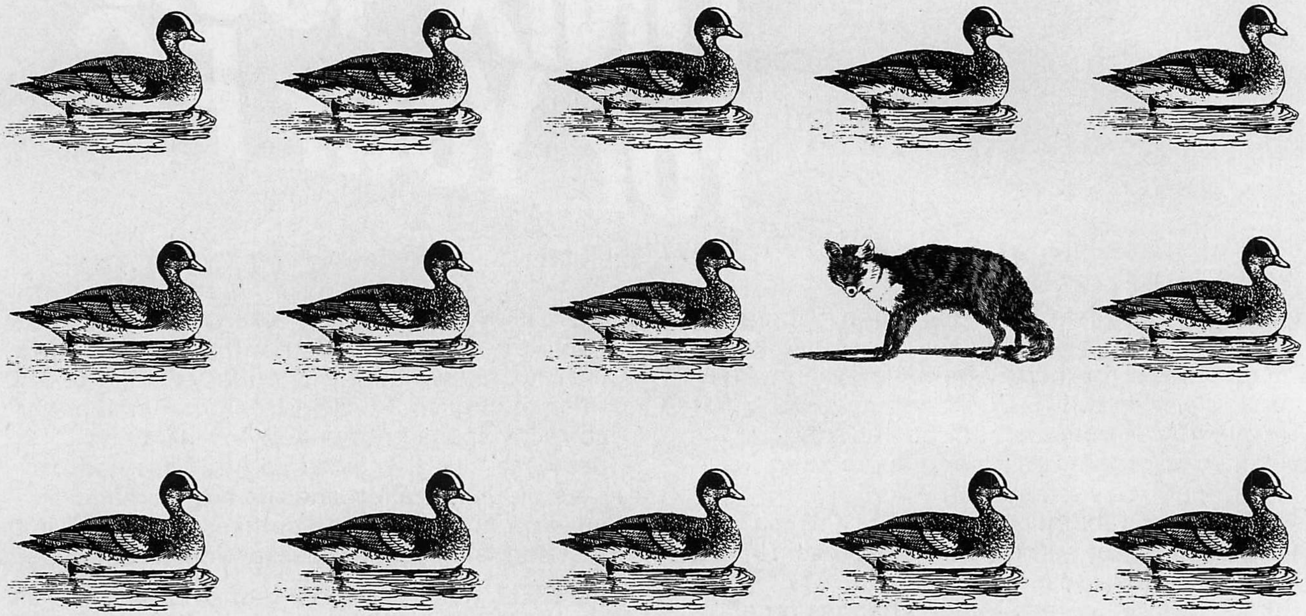

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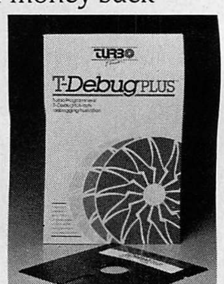

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CIRCLE NO. 219 ON READER SERVICE CARD

vide a constant time base when performing joystick readings should work properly in the Access 386.

Microsoft Windows 1.01 and Microsoft Word 3.1 were run to test graphics capabilities and the mouse. Microsoft Word 2.0 was run to test the ability of the Access 386 to run copy-protected software. Borland's SuperKey 1.03A, SideKick 1.56A, and Turbo Lightning 1.00A tested memory-resident programs. Living Videotext's Ready! 1.00d and Intel's QUIKMEM2 RAM disk were used to test expanded memory— both Above Board expanded memory and QEMM's emulated expanded memory. IBM's VDISK 3.2 was used to test the ability to switch into and out of protected mode. FastBack, from Fifth Generation Systems, tested DMA, and Hayes' Smartcom II tested the Smartmodem 1200B. IBM's AT Advanced Diagnostics 2.0 software, which includes IBM's SETUP program, gave a check of AT compatibility.

The only major incompatibility encountered while using the tested software was between Microsoft Windows and the Microsoft bus mouse. Another compatibility problem was encountered with Windows, but it is neither major nor unique to the Access 386. Microsoft's RAMDrive program, which creates an extended-memory RAM disk, failed to load. RAMDrive uses an undocumented 80286 instruction that is not supported by the 80386. The failure of RAMDrive to run is not a serious problem because IBM's VDISK, which comes with DOS and performs the same function, works perfectly on the Access 386.

Ready! displayed an odd incompatibility when used with the Intel Above Board and Intel's EMM (expanded memory manager). When Ready! was memory-resident with this hardware configuration, EMM would report an error and fail to reinitialize on a warm boot. On the next warm boot, however, EMM would initialize properly. When Ready! was used with Quarterdeck's QEMM expanded memory manager, warm boots did not present a problem.

Following the standard hardware and software tests, five programs were run from the *PC Tech Journal* AT Evaluation Suite. ATBIOS checks the BIOS and BIOS data areas. ATKEY checks for keyboard compatibility. ATFLOAT measures floating-point operations with the numeric coprocessor installed. ATDISK measures hard-disk performance. ATPERF measures CPU and numeric coprocessor clock rates, as well as memory access times. Table 2 lists the results of the Access 386 in comparison with the IBM AT and the Compaq Desk-

pro 386 on these tests. Bar graphs in figure 1 present comparisons for RAM instruction fetch, RAM read and write times, ROM read times, and EMM read and write times.

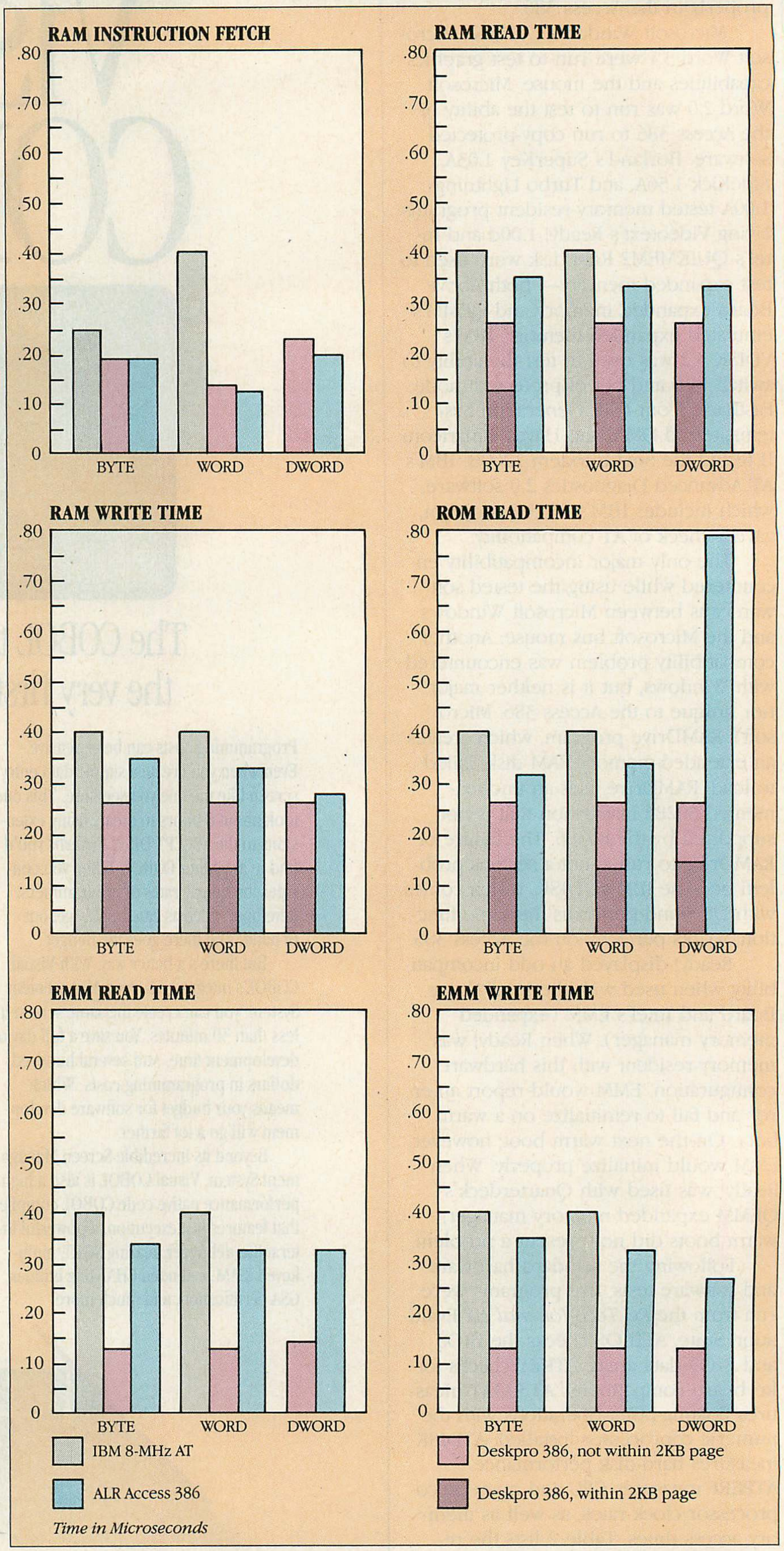
ATBIOS showed that the Access 386 uses the BIOS data area in the same way that the IBM AT does. The BIOS has a Phoenix Technologies copyright and a date of 10/28/86. ATKEY verified the compatibility of the ALR enhanced keyboard with the IBM AT keyboard. ATFLOAT reported that the Access 386 processes floating-point operations 2.2 times as fast as an 8-MHz AT. This is a reasonable finding because the 80386 runs at 16 MHz and the 80287 runs at 10 MHz (as opposed to 8 MHz and 5.33 MHz, respectively, on the AT). ATDISK found that the 42MB hard disk in the Access 386 is a high-performance drive, with significantly faster track-to-track and average seek times than the drive in the AT.

Given the potential for extremely high performance by the 80386, the results of ATPERF indicate that the Access 386 is a very fast AT, but perhaps not as fast as might be expected with a 16-MHz 80386 and interleaved, address-pipelined, 32-bit memory. The Access 386 does excel at instruction fetching, because of the sequential nature of instruction fetches and the interleaved memory architecture of the Access 386. In no other performance category does the Access 386 outperform the AT by as much as 25 percent; expanded memory and video memory access is actually slower than the AT. By contrast, the Compaq Deskpro 386 outperforms the Access 386 by a considerable margin in all areas of the performance tests save instruction fetching.

The slow EMM access time compared with the Compaq 386 is explained by the differences in memory architecture. However, the Access 386 is faster than the 8-MHz AT.

The slow video write time is a function of the way the Access 386 handles 8-bit expansion boards. In the Access 386, 8-bit boards are effectively slowed down even below the 8-MHz speed at which 16-bit boards are run; 13 cycles are required to access 8-bit memory rather than the 8 cycles required to access 16-bit memory. This is due to the more conservative synchronizing and timing specifications on the Intel iSBC bus than those found on the Compaq Deskpro 386. Because video memory is 8-bit memory, these extra cycles are inserted into each CPU display memory access, and these extra cycles slow video memory performance.

FIGURE 1: *Performance Comparison*



The Compaq Deskpro 386 has a copy of its 16-bit ROM in 32-bit RAM. This enables its DWORD ROM read time to be much faster than that of the Access 386.

TABLE 2: *Compatibility and Performance Tests*

	8-MHz AT, 30MB DISK[a]	DESKPRO 386, 40MB DISK	ACCESS 386, 42MB DISK
ATBIOS			
ROM BIOS date	11/15/85	08/19/86	10/28/86
ATPERF			
Average RAM instruction fetch (μs)			
BYTE	.250	.19	.19
WORD	.403	.14	.13
DWORD	N/A	.23	.20
Average RAM read time (μs)			
BYTE	.401	.13/.26	.35
WORD	.401	.13/.26	.33
DWORD	N/A	.14/.26	.33
Average RAM write time (μs)			
BYTE	.401	.13/.26	.35
WORD	.401	.13/.26	.33
DWORD	N/A	.13/.26	.27
Average ROM read time (μs)			
BYTE	.401	.13/.26[b]	.32
WORD	.401	.13/.26[b]	.33
DWORD	N/A	.13/.26[b]	.79
Average CGA video write time (μs)			
BYTE	1.208	1.21	1.55
WORD	2.415	2.42	2.80
DWORD	N/A	4.83	5.62
Average EMM read time (μs)			
BYTE	.402	.13[c]	.34[d]
WORD	.402	.13[c]	.33[d]
DWORD	N/A	.14	.33
Average EMM write time (μs)			
BYTE	.402	.13[c]	.35[d]
WORD	.402	.13[c]	.33[d]
DWORD	N/A	.13	.27
CPU clock rate (MHz)	8.0	16.0	16.0
Numeric coprocessor clock rate (MHz)	5.3	8.0	10.0
Refresh overhead (%)	7.1	15	6.1
RAM read/write wait states	1/1	0/0	3/2
ROM read wait states	1	2	3
Video write wait states (CGA)	8	17	22
EMM read/write wait states	1/1	0/1[c]	3/2[d]
ATFLOAT			
Performance as percentage relative to AT	100	180	220
ATDISK			
Sectors/track	17	17	17
Heads	5	5	5
Cylinders	731	978	1,022
Total space (million bytes)	31.81	42.56	44.48
Track-track seek time (ms)	6.0	4.1	4.1
Average seek time (ms)	37.1	4.1	30.4
Effective transfer rate (KB/sec)	170.1	254.5	170.1
DOS file I/O (sec)	7.3	7.4	5.3
Interleave	3	2	3

[a] *The figures for the IBM AT are the average results from several machines, whereas the results from the ALR Access 386 and the Compaq Deskpro 386 are taken only from the review sample model.*
[b] *Same as RAM read (see "The New Standard," Steven Armbrust and Ted Forgeron, March 1987, p. 48).*
[c] *EMM measurements were taken using the Deskpro 386's CEMM driver and built-in memory.*
[d] *EMM measurements were taken using the Access 386's extended memory configured as expanded memory with the QEMM expanded memory manager.*

The Access 386 video write time is fairly long. The RAM read times for ATPERF show that the interleave memory is being read with two or three wait states.

The relatively slow RAM access times are explained by the nature of the test and show that the ATPERF test ran with the memory system inserting two wait states. Testing the performance of 80386-based computers is a complex matter, involving the interaction of code and the memory system, and no single test can be a reliable indicator of overall performance. The times reported in ATPERF for RAM reads and writes are not the best times of which the 80386 and the memory system in the Access 386 are capable, indicating that on many memory accesses the interleaved bank being accessed had not yet recovered from the previous access. A custom designed test for the ALR machine could show the memory system working at its best theoretical performance of one wait state, but performance will vary from application to application. In day-to-day use, the Access 386 proved to be much faster than an 8-MHz AT—an informal estimate is that it is nearly two times as fast.

WEAK DOCUMENTATION

Documentation is currently a weak point of the Access 386. It appears to have been done in a hurry, no doubt because ALR wanted to introduce the Access 386 quickly. (The company's promotional material indicates that it is "the company that first put the power of the 80386 on your desk.")

The documentation consists of a single 87-page, spiral-bound *User's-Technical* Manual. It is rife with typographical errors, is sometimes inaccurate, is often incomplete, and lacks an index. As the title implies, the manual is half a user's guide and half a technical manual. The user's guide section describes an earlier version of the Access 386 than the review machine, with photos and drawings to match.

The user's guide portion provides basic set-up and installation instructions. Topics such as how to take care of a diskette and how to unpack the computer are covered in detail. However, the guide never makes reference to the SETUP program used to set the CMOS RAM. In fact, as discussed above, the only documentation for the software on the setup/utilities diskette is contained in README files on that diskette.

Other important topics are covered in a scattershot and sometimes misleading fashion. For example, only two sentences are devoted to DOS, while three pages are spent on a step-by-step discussion of partitioning a hard disk.

The technical portion of the manual contains highly technical informa-

tion about both the system unit and options, some of which appears to have been photocopied from other ALR manuals. ALR's options are available for AT- and XT-compatible computers as well, and the documentation of the options tends to refer to these computers rather than the Access 386.

An operations manual is included with DESQview, which is bundled with the Access 386 system. This manual is well done, but it makes no reference to the ability of DESQview to take advantage of the virtual-8086 mode of the 80386 in order to process up to nine separate DOS tasks concurrently.

In short, the documentation for the Access 386 is simply not up to the high standards of the machine itself.

ALR's warranty covers parts and labor for a full year, a significant improvement on the usual 90-day coverage. Warranty repairs can be performed either by an ALR-authorized dealer or by factory depot service. Technical support is available with ALR's technical support telephone line between the hours of 10 a.m. and 8 p.m.

AN AFFORDABLE DOOR

The Access 386 is a solid workhorse among 386 machines, filling two roles well. As an AT compatible it is spectacularly fast, proving in day-to-day use to be roughly twice as fast at running currently available software as an 8-MHz AT. As a 386-based computer, it fully supports the features that will make possible the transition from DOS to more powerful environments, including 32-bit operation, a 4GB linear address space, multitasking, and virtual-8086 mode. While the Access 386 is not the most sophisticated or fastest 386-based computer, it is nonetheless comparable to its competitors in functionality—especially in the basic Access 386B configuration—and it is significantly less expensive than the current 386 standard, the Compaq Deskpro 386.

The Access 386 does have some rough edges, however. Microsoft Windows does not work with Microsoft's bus mouse, although it does function properly with the serial mouse, and the bus mouse does work with Microsoft Word. Cheetah's zero-wait-state memory does not work at all. Software running in high DOS memory may slow down to near-AT speed unless QEMM and the 32-bit memory board are used to top off DOS. The many jumpers on the motherboard are difficult to use and should be replaced with switch blocks. Finally, ALR must expand and improve its documentation.

While the above items cannot be considered trivial, they are minor in light of the tremendous capabilities of this computer. By using the 80386 processor and pricing the Access 386 between ATs and competing 80386-based computers, ALR has opened an affordable door to the 80386-based environments and applications of the future. ALR has built a computer that should be judged today as a very high-performance AT compatible at a reasonable price—with the tremendous potential of the 80386 built in, awaiting the 32-bit software of tomorrow.

Advanced Logic Research, Inc.
10 Chrysler
Irvine, CA 92718
714/581-6770
Access 386

CIRCLE 346 ON READER SERVICE CARD

Michael Abrash and Dan Illowsky are senior software engineers for Orion Instruments in Redwood, California; they are coauthors of Graphics for the IBM PC *(Howard W. Sams Company, 1984) and publishers of arcade games for the PC from Funtastics, Inc.*

DOS Exception Handling

DOS error and exception handling methods allow an application program to run smoothly under worst-case conditions.

DAN ROLLINS

A seamless user interface is taken for granted in a professionally designed application. Colorful screens of pop-up windows, pull-down menus, and neatly framed status lines are expected to remain functional despite any abuse that a user might subject them to. An attempt to write to an empty disk drive should not paste the "Abort, Retry, Ignore" message in the middle of a carefully constructed screen. Even more important than cosmetics is the reliability of an application, and that too should not be compromised by user actions. Applications should be designed to operate under worst-case conditions. For example, can the application's data survive a Ctrl-Break in the middle of writing a file?

Ctrl-Break handling and critical device errors tend to be overlooked during program development and take on ominous importance about one week before an application's release date. A critical error is a device error that forces DOS to shut down activity until the problem is resolved. Ctrl-Break is usually defined as a request to abort or abnormally end an executing program. By default, Ctrl-Break causes an immediate exit to DOS.

At the lowest level, the keyboard interrupt (09H) is generated by the hardware every time a key is pressed or released. The routine that services this interrupt (normally residing in BIOS, unless replaced by a terminate-and-stay-resident utility) interprets each keystroke, usually placing an ASCII or extended ASCII value into a keyboard buffer. Certain keystrokes are given special treatment. The Shift-PrtSc keystroke, for example, invokes interrupt 05H to print the contents of the screen, and the SysReq key on ATs causes an interrupt 15H. Similarly, the Ctrl-Break keystroke causes an interrupt 1BH.

Interrupt 1BH can be intercepted at this lowest level. For example, setting interrupt 1BH to point to an IRET that is located somewhere in ROM causes Ctrl-Break to be ignored throughout the system. However, DOS provides a level of insulation for application programs that makes this low-level interception unnecessary and undesirable.

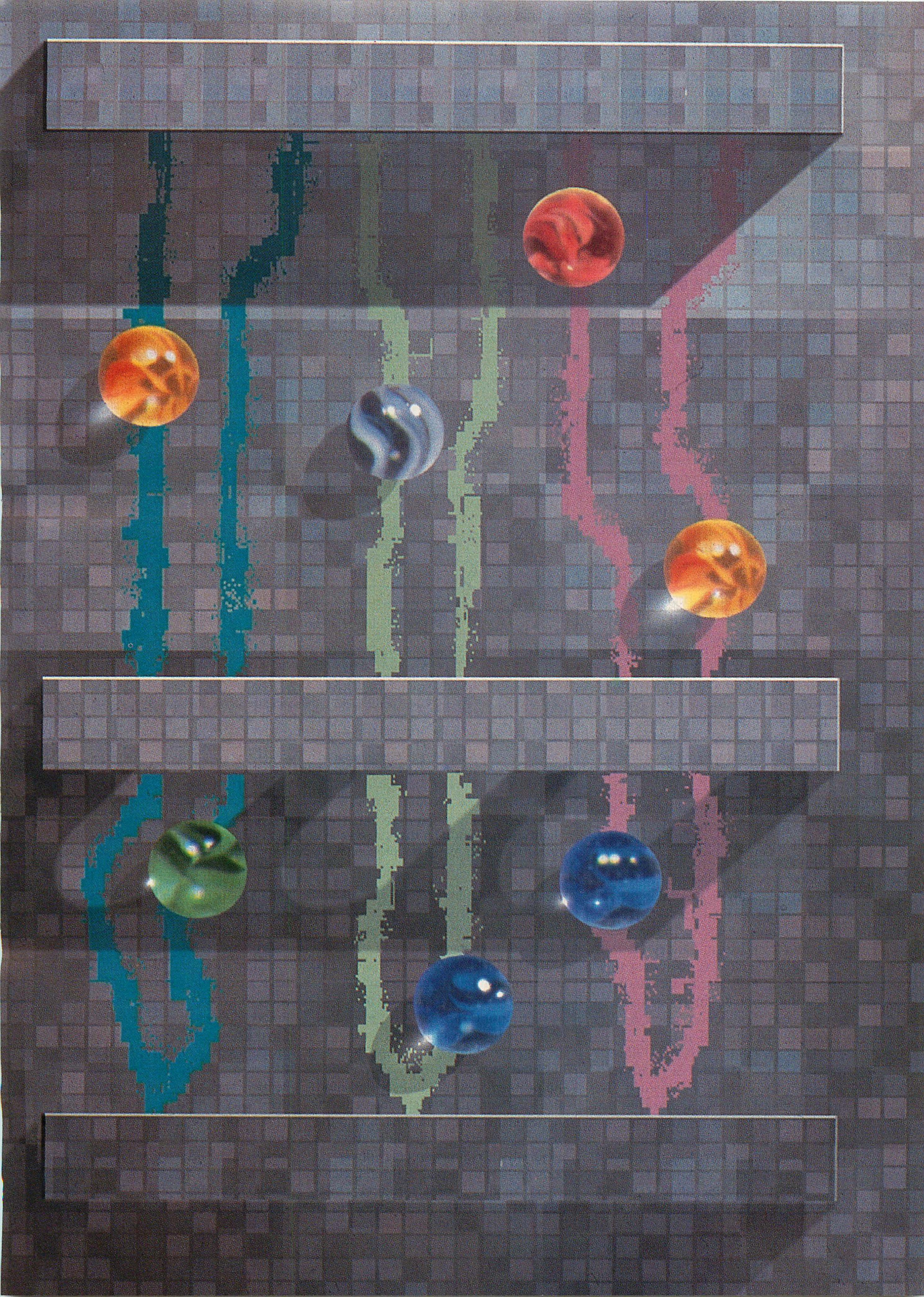
The DOS Ctrl-Break handler for interrupt 1BH sets an internal flag to indicate that a break has occurred. This flag may go unnoticed until DOS deigns to look at it. By default, DOS checks its break flag only during character I/O, specifically when processing the standard I/O, printer, and auxiliary devices. Because some programs run a long time without using these functions, a press of Ctrl-Break may not have the immediate effect desired.

DOS can be forced to pay more attention to the break status with the DOS command BREAK ON, or by placing BREAK=ON in the CONFIG.SYS file, or by using DOS function 33H (Ctrl-Break check) with AL=1 and DL=1. When BREAK is ON, DOS checks its break flag upon entry into nearly all DOS functions. The only exceptions are functions 06H (direct console I/O) and 07H (direct console input without echo). These functions are useful for password-input routines and for input routines used in processing Ctrl-Break and critical errors.

When DOS recognizes that a Ctrl-Break has occurred, it invokes the DOS break interrupt (23H). This interrupt is normally set to execute code within COMMAND.COM, which aborts the executing process and, if a batch file is being processed, displays the "Terminate batch job (Y/N)?" prompt.

The documented and the most acceptable method for performing Ctrl-

COMPUTER GRAPHIC • NATALE/EAST



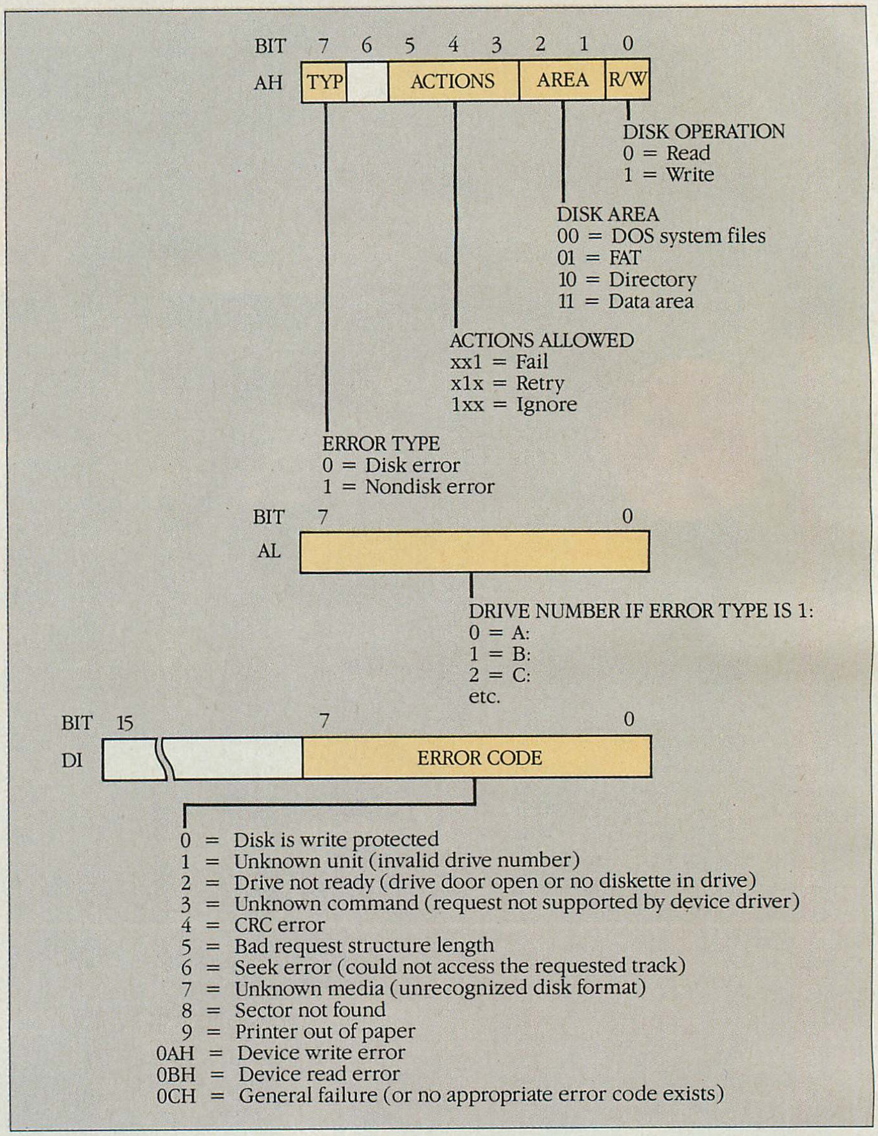
Break handling is to intercept interrupt 23H. Any custom handler installed in this interrupt is temporary; the original handler is restored when the program exits, even if the installing program remains resident in memory.

The following DOS features make this interrupt safe and easy to use:

- DOS function 25H (set interrupt vector) can be used to point interrupt 23H to the custom break handler.
- When Ctrl-Break is pressed, the break flag is set by interrupt 1BH. Subsequently, when a function that tests the break flag is about to be performed, DOS invokes interrupt 23H, passing control to the custom break handler.
- When the break handler receives control, the registers are set as they were on entry to the DOS function that detected the break flag. This feature can be used to find which DOS function was interrupted by the sensing of the break flag. If execution of this function is to be resumed after the break handler is finished, then any registers to be used within the break handler should be saved.
- DOS is in a relatively stable state. The *DOS Technical Reference* manual, version 3.2, claims that a break handler is unrestricted in the DOS functions it can perform. In reality, DOS can lock up while the break handler is executing if certain DOS I/O functions are performed and the user then presses Ctrl-Break again.
- After closing files, setting flags, and cleaning up the screen, the user can return to a program by executing an IRET. This causes the interrupted DOS function to be restarted, so any registers that have been used must be restored before returning. The application then will continue as if the break did not occur.
- If control is to be returned to the parent process without resuming the interrupted program, then the break handler must set the carry flag and execute a far return. A far return with the carry flag clear is equivalent to an exit via an IRET. The break handler also can terminate the program by using a DOS termination function, interrupt 20H or function 4CH.

Listing 1 (BRK_TEST.ASM) illustrates the basic concepts of capturing and using the Ctrl-Break interrupt. The first part installs the local interrupt handler and then begins printing a message in an endless loop, using routines included from listing 3, CE_CONIO.ASM, (also used in listing 2). When DOS recognizes Ctrl-Break, the BRK_HANDLER procedure displays a prompt, receives

FIGURE 1: *Interrupt 24H Handler Error Indicators*



Adapted from the IBM PC-DOS Technical Reference manual

Upon entry into an interrupt 24H critical error handler, the AX and DI registers indicate the condition that caused the error and available corrective actions. If the error type (AH bit 7) is a disk error, AL contains the drive number.

user input, and then acts upon it either to resume the program or exit to DOS.

DOS function 09H (print string) was used in an earlier version of BRK_HANDLER to display messages and DOS function 0AH (buffered keyboard input) to receive user input. This worked until Ctrl-Break was pressed while the break handler was active, causing the system to lock up. The machine had to be turned off to clear the problem. Several unsuccessful modifications were tried, including redirecting interrupt 23H to an IRET within the break handler. One reliable method uses only DOS function 06H (direct console I/O) to display and input characters. Another approach redirects interrupt 1BH (the BIOS break vector) to an IRET instruction while processing Ctrl-Break and restores its value upon leaving the break handler; this disables BIOS break notification to DOS.

The most desirable approach is to have a program recognize Ctrl-Break as soon as possible. Listing 1 uses DOS function 33H (Ctrl-Break check) to force extended break testing. (Some programs may not work well with BREAK turned on; see "A Resident Exception Manager," Programming Practices, Ted Mirecki, this issue, p. 170).

Proper break handling is important in two other areas. Pop-up programs may need to take special action to avoid problems with Ctrl-Break while they are active. Any interrupt 23H break handler put in place when the pop-up program

FIGURE 2: *Interrupt 24H Handler Stack Upon Entry*

OFFSET FROM SP (Hexadecimal)	REGISTER SAVED	DESCRIPTION
+00	IP	Pushed by DOS function executing interrupt 24H; used in an IRET from the error handler to DOS
+02	CS	
+04	FLAGS	
+06	AX	(AH contains a DOS function number)
+08	BX	Registers of the application program that invoked the DOS function that failed
+0A	CX	
+0C	DX	
+0E	SI	
+10	DI	
+12	BP	
+14	DS	
+16	ES	
+18	IP	Pushed by application program in executing the interrupt 21H function that failed; may be used to IRET the application.
+1A	CS	
+1C	FLAGS	

Adapted from the IBM PC-DOS Technical Reference manual

When the critical error handler is called, the stack top contains the far return address to the failing DOS function. Further into the stack are the application's registers and return address, saved when the DOS call originally was made.

is installed is disabled after the installation. DOS restores COMMAND.COM's break handler upon termination, even when the program is exited via one of the terminate-and-stay-resident services (interrupt 27H or DOS function 31H).

When the pop-up program becomes active, the break vector for the interrupted program continues to be in effect. Interrupt 23H should be intercepted to execute a local break handler while the pop-up program is active, then the vector is restored when the user exits the pop-up program.

DOS shell programs are an important consideration. When a program uses DOS function 4BH (EXEC) to load and execute a child process, DOS saves the current interrupt 23H vector into offset 0EH of the program segment prefix (PSP) of the child process. It then sets interrupt 23H to point to the code directly following the call to the EXEC function. The result of a Ctrl-Break is an immediate return to the parent. When the child program exits, DOS restores the parent's Ctrl-Break vector from the child's PSP. This is significant because a parent process must provide Ctrl-Break services for its children.

The parent can determine how the child process is terminated by calling DOS function 4DH (get return code). The high-order byte of the code returned by this function is 0 for normal termination via interrupt 20H or function 4CH, 1 for termination with Ctrl-Break, 2 if terminated by a critical error, and 3 if terminated with function 31H (terminate and stay resident).

However, if a child process is executed indirectly by means of a second copy of the command processor, as is done frequently in DOS shell programs, then the return code comes from COMMAND.COM, and not from the child program. COMMAND.COM, in this case, repoints interrupt 23H to its own Ctrl-Break handler, so that the parent does not need to make provisions for servicing interrupt 23H. In fact, one of the primary reasons for invoking COMMAND.COM is to use its built-in interrupt handling routines.

CRITICAL ERROR HANDLING

The most common critical errors are disk problems, but printers and other devices can cause critical errors. The standard DOS critical error handler is the routine that displays the infamous "Abort, Retry, Ignore" prompt. For most applications, the primary concern is to avoid this line and display a friendlier message. A secondary consideration is to limit the user's options—depending on circumstance, either the abort or ignore alternatives may be unacceptable.

Interrupt vector 24H contains the address of the current error handler. The address of the error handler of a program's parent (the default error handler for the program) can be found in the PSP at offset 12H.

As with the Ctrl-Break handler, intercepting and replacing the critical error handler is fully documented. Just like the Ctrl-Break handler, a custom error handler is temporary; the parent's interrupt 24H is restored from the PSP when a program terminates.

When the error handler is given control, the following takes place:

- The AH register and the lower 8 bits of the DI register indicate what the cause of the error was (see figure 1). If it is a disk error, the drive number is in the AL register.
- The registers of the program that made the failing DOS request are put on the stack (see figure 2).
- The register pair BP:SI contains the address of the device header of the device driver that indicated the failure (see figure 3).
- Because DOS is non-reentrant, the error handler must not use DOS functions higher than 0CH, with the exception of 59H (which is extended error reporting).
- The DOS direct disk access services, interrupts 25H and 26H, do not invoke the error handler. When the error handler receives control, it is certain that an interrupt 21H function was disrupted by the critical error.

Typically, the error handler should try to solve the problem—for example, by asking the user to close the diskette drive door or turn the printer on. The values in AX and DI can be used to decide which message, if any, to display.

After processing the error, the user can return to DOS via an IRET, passing back one of the exit codes shown in table 1. For DOS 2.x compatibility, the only options are to abort, retry, or ignore. Version 3.x offers the user an alternative: DOS can be told to cancel the operation and return to the application with a DOS error return code.

Listing 2 (CE_TEST.ASM), contains a typical critical error handler. It copes with common disk errors and provides general-purpose handling of character-device problems. The error handler has two options: retry the operation or cancel. A cancel request passes control back to the application with the carry flag set and a DOS error return code.

CE_TEST.ASM repoints the interrupt 24H critical error vector to the local routine CRIT_ERR, which will handle any errors encountered in the subsequent I/O operations. The first of these operations is the creation of a file on drive A:. To activate the error-handling routine, the user opens the

FIGURE 3: *Device Header Structure*

OFFSET	SIZE (bytes)	DESCRIPTION
00	4	Far pointer to next device header (OFFFFH = last driver)
04	2	Device attribute (bit 15 is 1 if character device)
06	2	Offset of device strategy (preparation) routine
08	2	Offset of device interrupt (action) routine
0AH	8	ASCII name (character device) or binary subunit (block device)

Adapted from the IBM PC-DOS Technical Reference manual

Upon entry into the critical error handler, the BP:SI register pair contains the segment:offset of the header of the device driver that signaled the error.

drive door or inserts an unformatted disk when prompted.

In the next step, CE_TEST.ASM attempts to write some text to the printer. Leaving the printer off-line or removing the paper shows how CE_TEST.ASM deals with an error.

Unplugging the printer cable during the printer-error test results in a long delay before the error message is displayed. This is because DOS retries the device three times before it decides to invoke the error handler, and it must wait for a printer time-out on each retry. This delay can be avoided by using interrupt 17H (BIOS printer functions) with AH=2 to read the status of the printer before starting to print. Then the critical error handler works as a backup in case the printer is turned off or runs out of paper while printing.

The CRIT_ERR routine in listing 2 displays an error message and prompts the user to determine what to do next. Depending upon the response, it exits to DOS or to the application. The error handler tries to be as invisible to the program as possible; it saves the screen contents, displays messages in a reverse-video window, and restores the screen upon finishing its tasks.

CRIT_ERR recognizes disk errors by testing AH and composes a different message for character device errors. The nature of the problem is determined by the value in DI. The name of the device is found from AL (for disks) or from the device header passed in BP:SI (for character devices).

The user can retry or cancel the operation. The retry logic simply restores the registers as they were upon entry and returns to DOS via IRET, passing back a code of 1 in AL. DOS then repeats the call to the I/O function.

The cancel logic is compatible with both DOS 2.x and 3.x. Using the stack structure shown in figure 2, it discards from the stack the return address and flags saved by the DOS routine when it executed interrupt 24H, then it restores the application's registers. The resulting state of the stack is such that a subsequent IRET returns not to the DOS routine that encountered the error, but directly to the program that invoked the DOS I/O function. Before returning, the error handler places an appropriate error code in AX and sets the carry flag. Note that the carry must be set not in the current flags, but in the flag image on the stack, from where it will be restored when the IRET is executed.

The effect is that the application receives a recognizable DOS error code that it can process as it sees fit. The error code returned to the application is calculated by adding 13H to the entry-value of DI, so that the critical error codes are mapped to the corresponding

THANKS FOR THE MEMORIES

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DOS codes. This is convenient for most applications, but the user can choose to return any error code if desired.

However, the documentation states that returning to the application in this way leaves DOS in an "unstable state" until a function higher than 0CH is called. Stability will be restored only if the subsequently called function does not itself encounter a critical error. One possibility, which is demonstrated in the CE_TEST program, is to call function 19H (get current disk drive), which cannot return an error.

If the application is running under DOS 3.x, steps similar to the retry logic can be followed: IRET to DOS with a return code of 3 in the AL register. DOS eventually returns to the application with the carry flag set. The DOS 3.x-specific application, upon querying DOS function 59H, will learn that error number 53H (device failure) occurred, but not the reason for the failure.

While in the error handler, DOS function 30H should not be used to determine which version of DOS is active. If it is necessary to execute separate logic for DOS 2.x and 3.x, the user must determine the DOS version number before an error occurs and put it in a global variable where the error handler is able to find it.

TABLE 1: *DOS Error-recovery Action*

AL	DESCRIPTION
0	Ignore the error.
1	Retry the operation. This is invoked after the user is given a chance to close the drive door, fix the printer, etc.
2	Abort. This causes DOS to execute interrupt 23H, the DOS Break routine. This normally causes an exit to the parent process.
3	Fail. This tells DOS to return to the application, indicating an error occurred during the operation. Do not return this value unless DOS 3.x is active.

When an error handler returns to DOS, it passes back a value in AL to indicate how execution is to proceed. Option AL=3 (fail) was introduced with DOS 3.0.

Pop-up programs and shells must pay special attention to the DOS critical error vector. When a pop-up program is activated, it must direct control to its own error handler; how an application will handle an error is unpredictable. If the existing error handler were to abort to DOS, the machine would be left in a very disrupted condition.

Shell-type programs (any program that uses DOS function 4BH to execute a child process) must be aware that the error handler in effect at the time the EXEC function is invoked will be used as the default error handler for the child process. In most cases the normal DOS error handler should be restored before EXEC is invoked, because the child program's error handler is not likely to manage all error conditions as well as the normal COMMAND.COM error handler. The easiest method of reinstating the DOS error handler is to EXEC COMMAND.COM, letting it in turn, EXEC the child program.

EXTENDED ERROR REPORTING

Beginning with version 3.0, DOS has provided a service to consolidate and simplify normal error handling for applications. DOS function 59H (get extended error) returns the information shown in table 2. This service can be used only after a DOS function has returned an error indication. It returns codes describing the specific error, the class of error, where the error occurred, and a suggested action to take.

This function works after any DOS error, including errors on old-style file control block (FCB) operations indicated by AL=0FFH, errors indicated by the carry flag being set, and device errors handled by customized interrupt 24H critical error handlers. Error codes 13H through 1FH returned by function 59H are the same as codes 0 through 0CH that are found in the DI register by a critical error handler.

DOS function 59H allows the developer to write general-purpose exception routines to eliminate some in-line code. A general-purpose error handler subroutine is a convenient way to link into a variety of application programs. Such an error handler could display prompts, get user input, and take actions in a generic way.

This extended error reporting function is a mixed blessing. The majority of applications must continue to write down to DOS 2.x to maintain the broadest possible compatibility. Applications that use DOS file locking or are specifically written for the PC/AT or PC Convertible (and thus must run on DOS 3.0 or later) can take full advantage of this function. Other applications must rely on DOS 2.x error conventions or

TABLE 2: *Extended Error Codes*

REGISTER CONTENTS	DESCRIPTION
ERROR CODE IN AX	
00	No error
01	Invalid function number
02	File not found
03	Path not found
04	Too many open files (no file handles available)
05	Access denied
06	Invalid file handle
07	Memory control blocks destroyed
08	Insufficient memory
09	Invalid memory block address
0AH	Invalid environment
0BH	Invalid format
0CH	Invalid access code
0DH	Invalid data
0EH	Reserved
0FH	Invalid drive number
10H	Attempt to remove current directory
11H	Not same device
12H	No more matching files (after file-searching operation)
13H	Disk is write protected
14H	Unknown unit (invalid drive number)
15H	Drive not ready (door is open or no diskette is in the drive)
16H	Unknown command to the device driver
17H	Disk data error (CRC error)
18H	Bad request structure length
19H	Seek error (device driver could not access the requested track)
1AH	Unknown media (device driver could not recognize disk format)
1BH	Sector not found
1CH	Printer out of paper
1DH	Device write error
1EH	Device read error
1FH	General failure (or no appropriate error code exists)
20H	File-sharing violation
21H	File-locking violation
22H	Inappropriate disk change
23H	Too many FCBs in use (no FCBs available)
24H-4FH	Reserved
50H	File exists
51H	Reserved
52H	Cannot make
53H	Failure indicated by interrupt 24H (critical error handler returned AL=3)

Adapted from the IBM *PC-DOS Technical Reference* manual

provide two exception-handling paths, depending upon the version of DOS that is active.

Currently, DOS continues to be fully compatible with previous versions; that is, if the carry flag is set upon return from a DOS function, a valid error code can be expected in the AX register. However, the *DOS 3.x Technical Reference* manual does not list the specific errors expected for each function, and it states that new services in future releases of DOS may not provide accurate error information unless function 59H is used. Thus, when using file locking or other DOS 3.x-specific features, the developer is advised to invoke function 59H when an error is encountered.

Using function 59H is fairly straightforward. A typical sequence is

```
mov ah,fn_num
int 21H             ; DOS fn. Any error?
jnc no_err          ; no, continue
mov ah,59H          ; yes, get error info
int 21H
jmp err_proc        ; handle the error
no_err:             ; else continue
```

REGISTER CONTENTS	DESCRIPTION
ERROR CLASS IN BH	
1	Out of resource; no more memory, disk space, etc.
2	Temporary situation; try again later (file is locked, but it may become unlocked in a little while).
3	Authorization error; user was not allowed to do this.
4	Internal DOS error
5	Hardware failure
6	System software failure; DOS internal problem
7	Application program error; for example, DOS function 4FH (find next) before function 4EH (find first)
8	Not found; no more matching files, etc.
9	Bad format; usually unknown disk media format
0AH	Item locked
0BH	Media failure; usually disk read/write error
0CH	Already exists
0DH	Unknown error class; no appropriate code exists
SUGGESTED ACTION IN BL	
1	Retry now; try again immediately and the problem may be solved.
2	Delay and retry; wait a few seconds then retry. This is the action recommended when a file is locked (it may become unlocked in a few seconds).
3	User input error; the program tried to open a file (or take other action) on a drive or directory that does not exist. If the filespec was obtained from user input, then the user should be prompted to enter a different drive or path or filespec.
4	Abort the program; this usually indicates that the program contains a programming error; for example, a DOS function 4FH (find next) service was invoked before function 4EH (find first). The error has not damaged DOS, so any necessary clean-up may be performed before exiting to the parent.
5	Immediate exit; DOS is in an unhealthy state and should be exited immediately, without closing files or performing other clean-up operations.
6	Ignore the error.
7	Retry after user action; prompt the user for action (inserting a different diskette), then retry the failing DOS function.
LOCUS IN CH	
1	Unknown; DOS cannot pinpoint an area where the error occurred.
2	Block device error; error occurred on a disk drive
3	Reserved
4	Character device error; this is usually a printer error.
5	Memory error

DOS function 59H provides extended error reporting for applications that run under DOS 3.0 and above. This list includes all error codes defined up to DOS 3.2.

where the ERR_PROC routine handles errors depending upon the error code in AX, error class in BH, suggested action in BL, and error locus in CH.

Although DOS supplies a no error code of 0, the code does not appear following a successful DOS operation. Function 59H always reports on the most recent error, and the documentation does not suggest a way to reset the error code. Therefore, it is not possible unconditionally to call function 59H and then to branch depending on the results that are returned by it.

The manual warns against coding for specific error numbers and, instead, recommends using suggested actions to determine what to do. Note, however, that some of the suggested actions are slightly misleading. For example, BL=3 suggests that a user error occurred and that the program should prompt for new input. This action is recommended when the user tries to open a file or create a directory on a drive or path that does not exist. DOS cannot tell if a filespec was input by a user, hard-coded into a program, or obtained from the

DOS environment or other means—it always suggests that the user be prompted to reenter input.

When DOS suggests that the program "Abort with cleanup" (BL=4), it is usually saying that a programming error has occurred. For example, DOS recommends a shutdown if a file operation is attempted with a nonexistent handle or if function 4FH (find next matching file) is used before function 4EH (find first matching file). Even justified errors, such as requesting too large a block of memory in order to find the largest available block, cause DOS to suggest that the program should abort. This cowardly advice also is given for hardware errors such as a printer error encountered by a critical error handler.

Furthermore, a generic message, based on an error code and class, cannot be depended upon to provide meaningful information about a particular error. For example, if DOS function 56H (rename file) is used and the target filespec names a file that already exists, DOS indicates an "Access denied" error (AX=5) with an error class of "Permission problem" (BH=3). This may seem absurd, because the error class of "Already exists" (BH=0CH) is documented and would be ideal.

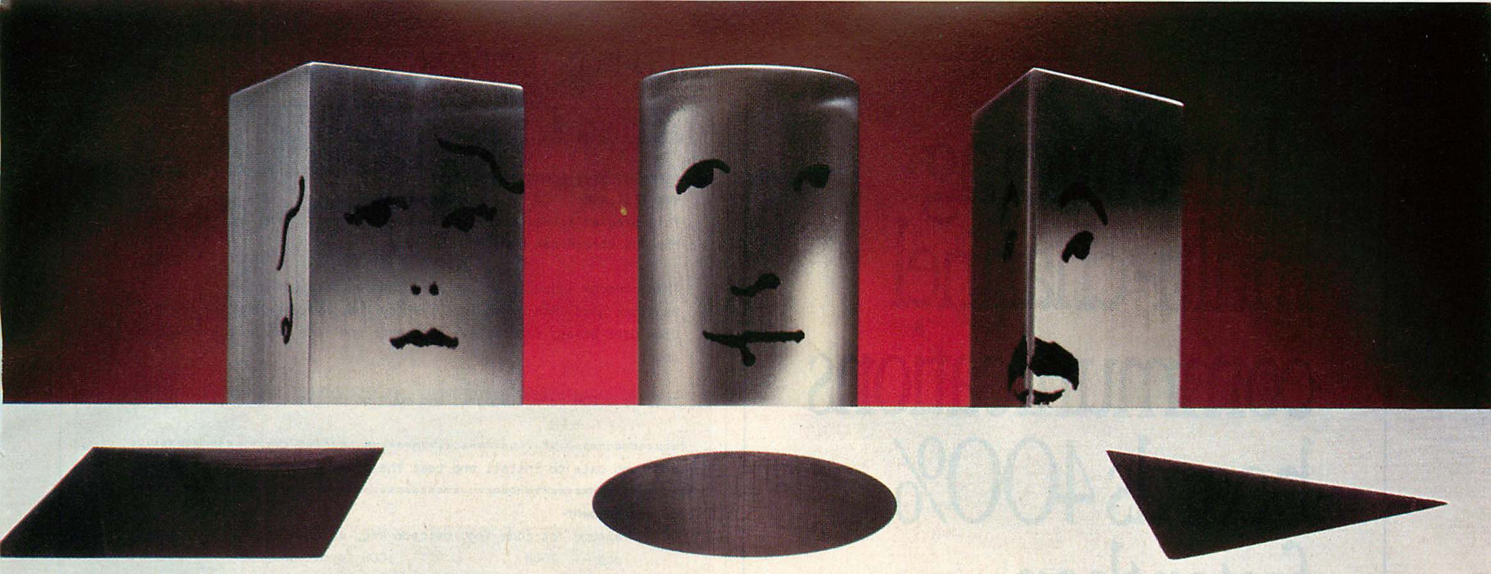
Because of the global nature of the way DOS handles extended error codes, a pop-up program might cause an interrupted application program to receive misleading error codes and advice from DOS. This could happen if a pop-up program were activated directly after a failing DOS operation but before the interrupted application could process the error. If the pop-up program experienced its own error, then when control returned to the application, it would receive the wrong error codes. Although this is an unlikely sequence of events, it is possible.

The most obtrusive errors are those that allow an unwanted exit to DOS or cause TTY-style messages to be scrawled upon the screen. Carefully crafted service routines that capture the Ctrl-Break and critical error interrupts can remedy most of these situations.

The method used to handle normal errors such as a full disk or an illegal file name, is a matter of programming style, common sense, and creative testing. The DOS extended error reporting function might help to simplify some exception processing for programs running under DOS 3.x. Considering the problems and inconsistencies with function 59H, and the fact that it must not be used in a DOS 2.x environment, it is not a complete answer to normal error handling. The best approach is the tried-and-true technique: simulate each potential error and see how DOS responds, then code the application to take action depending upon the context in which the error occurred.

Even if a program runs without a glitch 95 percent of the time, the other 5 percent will be noticed by end users. If developers could be certain that their programs would never run into a full disk or an off-line printer, programming would be much simpler. End users, however, inevitably will subject an application to worst-case conditions, and an application that is not reliable under those conditions eventually will not have many users. Error and exception handling is a prime consideration that should be built into a program in the early stages.

Dan Rollins is a consultant and freelance technical writer. He is the author of IBM PC: 8088 Macro Assembler Programming *(Macmillan, 1985). He also wrote the Flambeaux Software program DOS Help!, which won a Computer Press Association award.*



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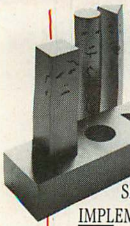

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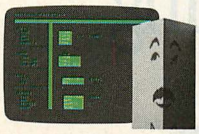

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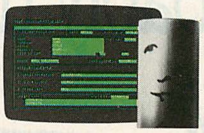

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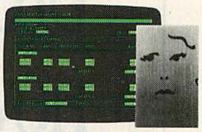

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LISTING 1: BRK_TEST.ASM

```
;===============================================================
; BRK_TEST.ASM              Dan Rollins            December 15, 1986
; This program illustrates techniques for intercepting and replacing
; the DOS Ctrl-Break handler.
;
; This program installs an INT 23H handler, sets DOS break-checking to
; ON, then goes into an endless display loop, wating for Ctrl-Break.
; Upon Ctrl-Break, it displays a message and lets the user continue or
; abort.
;
; This is a COM-format program and must be processed with EXE2BIN

;===============================================================
; Code and data to install and test the break handler
;===============================================================
code_seg segment
        assume  cs:code_seg, ds:code_seg, es:code_seg
        org     100H                    ;COM-format program

brk_test proc   near
        jmp     start

test_msg db     "Press Ctrl-Break...  $",0

start:  mov     al,23H                  ;DOS Ctrl-Break interrupt number
        mov     ah,25H                  ;fn replaces an INT vector
        mov     dx,offset brk_handler
        int     21H                     ;local break handler is in place

        mov     al,1                    ;change break-checking level
        mov     dl,1                    ;set BREAK=ON
        mov     ah,33H                  ;DOS break_check service
        int     21H

bt_10:  mov     dx,offset test_msg
        mov     ah,9                    ;DOS display_msg servce
        int     21H
        jmp     bt_10                   ;this loops endlessly until you
                                        ; press Ctrl-Break or Ctrl-C
brk_test endp

;===============================================================
; Start of Ctrl_Break handler code and data
;===============================================================

brk_msg db      " *Break* detected before DOS function "
fn_no   dw      ?
        db      " ",0dh,0ah
        db      " Exit or Continue? (Press E or C) ",0

brk_handler proc far
        push    es              ;save registers of interrupted DOS function
        push    ds
        push    bp
        push    si
        push    di
        push    dx
        push    cx
        push    bx
        push    ax
bh_10:
        mov     bx,cs                   ;address local data
        mov     ds,bx

        mov     al,ah                   ;put DOS function number in AL
        mov     ah,0
        mov     bl,10
        div     bl                      ;break into two decimal digits
        or      ax,3030H                ;force into ASCII characters
        mov     fn_no,ax                ;store into the message

        mov     dx,offset brk_msg ;display the message
        call    disp_msg

bh_20:  call    beep
        call    get_key
        or      al,32                   ;force response to lowercase
        cmp     al,'e'                  ;request to Exit?
        je      bh_30                   ; yes, go
```

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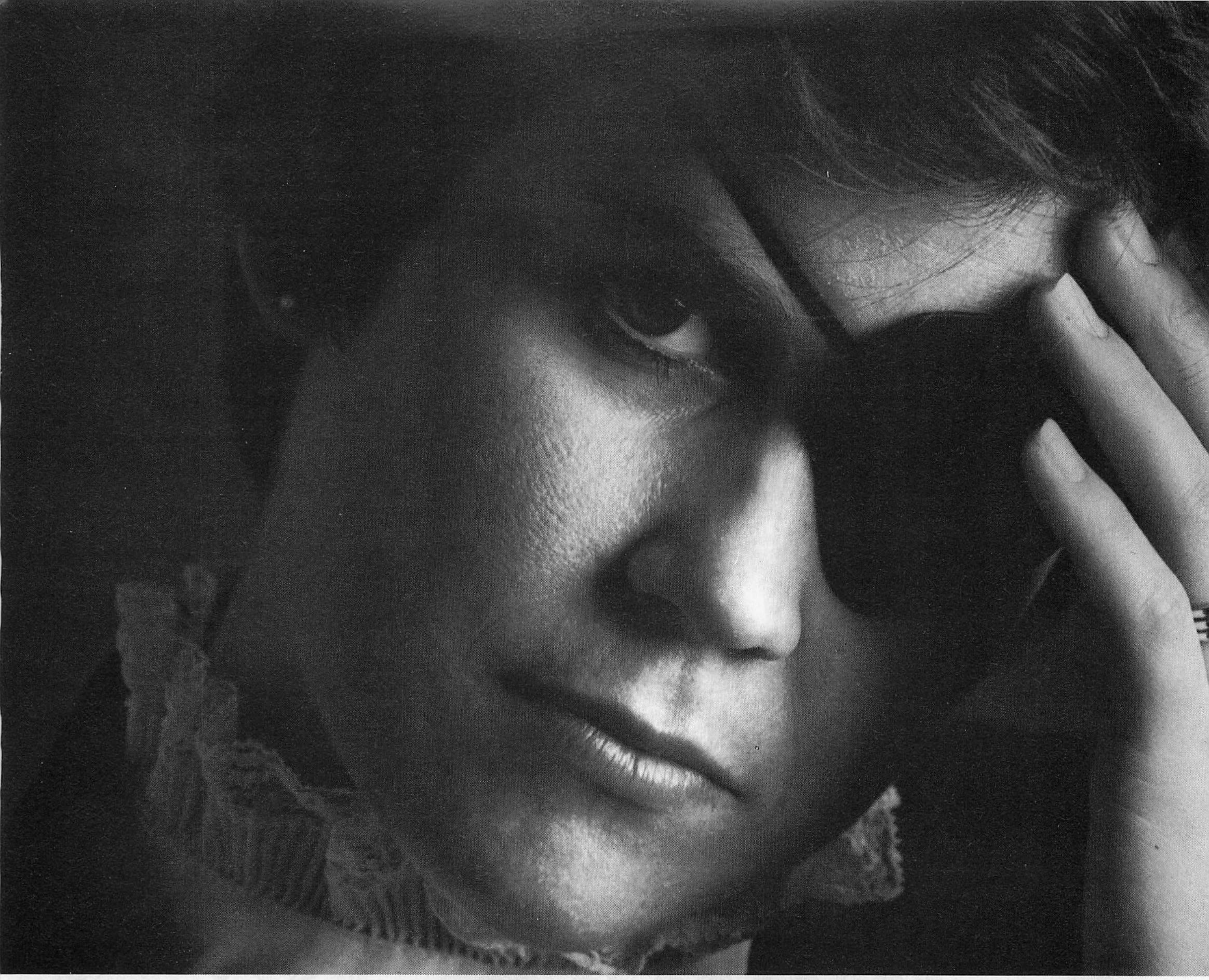
```
        cmp     al,'c'              ;request to Continue?
        je      bh_40               ; yes, go

        jmp     bh_20               ;invalid: loop back

bh_30:  stc                         ;set carry to indicate Exit
        jmp     bh_exit

bh_40:  clc                         ;clear carry to indicate Continue

bh_exit: pop    ax
        pop     bx
        pop     cx
        pop     dx
        pop     di
        pop     si
        pop     bp
        pop     ds
        pop     es
        ret                     ;FAR return to DOS
brk_handler endp

include ce_conio.asm            ;insert general-purpose routines

code_seg ends
        end     brk_test
```

LISTING 2: CE_TEST.ASM

```
;===================================================================
; CE_TEST               Dan Rollins                 December 15, 1986
; This program illustrates techniques for intercepting and replacing
; the DOS Critical Error handler.  It shows how to:
;     * save and restore the application screen
;     * make the error message popup in a window
;     * allow the error handler to return directly to the application
;       program, passing back a DOS error code (even for DOS 2.x).
;
; After installing an INT 24H handler, it attempts to open a file on
; drive A, then attempts to send characters to the printer.
;
; This is a COM-format program and must be processed with EXE2BIN

;====================================================================
; MACROS used in this listing
;====================================================================
$set_csr macro  line,clm            ;;this positions the cursor
        mov     dx,((line)*256)+clm
        mov     ah,2
        mov     bh,0
        int     10H
        endm
$disp   macro   string              ;;this displays a string
        ifnb    <string>
         mov     dx,offset string   ;;if string given, point DX to it
        endif                       ;; otherwise, assume DX is set
        call    disp_msg
        endm
;====================================================================
; Code and data to install and test the error handler.  This is
; the "application program" that is disrupted by a critical error.
;====================================================================
code_seg segment
        assume  cs:code_seg, ds:code_seg, es:code_seg
        org     100H          ;must have for COM-format programs

ce_test proc    near
        jmp     start

filespec    db  "a:\erase.me",0         ;filespec used in disk test

test_msg    db  "This is a test message ",0dh,0ah ;for printer test
MSG_LEN     equ ($-test_msg)

prtr_msg    db  "Printer error test.  Press a key...",0
disk_msg    db  "Disk A: error test. Press a key...",0
new_line    db  0dh,0ah,0

no_err_msg  db  "Returned from DOS function without error.",0dh,0ah,0
ret_err_msg db  "Error "
ret_code    dw  ?           ;this is filled with 2 ASCII digits
            db  " upon return from DOS function.",0ah,0dh,0
start:  mov     al,24H          ;DOS critical error interrupt number
        mov     ah,25H          ;function to replace an int vector
        mov     dx,offset crit_err
        int     21H             ;local error handler is in place

        $disp   disk_msg        ;display a message and await a key
        call    get_key
        $disp   new_line

        ;------ disk test just attempts to open a file on drive A
        mov     dx,offset filespec
        mov     cx,0            ;normal attribute
        mov     ah,3cH          ;create file
        int     21H
        jnc     ct_20           ;if no error, continue

        push    ax              ;else, stabilise DOS
        mov     ah,19H          ;  with dummy call to function 19H,
        int     21H             ;  get current drive
        pop     ax
        mov     bl,10           ;setup string with error number
        div     bl
        add     ax,3030H        ;force binary to ASCII
        mov     ret_code,ax
        $disp   ret_err_msg     ;and display the resulting string
        jmp     ct_30
ct_20:
        $disp   no_err_msg

ct_30:  ;------ printer test sends text to standard printer device
        $disp   prtr_msg        ;display a message and await a key
        call    get_key
        $disp   new_line
        mov     bx,4            ;handle reserved for standard printer
        mov     cx,MSG_LEN
        mov     dx,offset test_msg
        mov     ah,40H          ;DOS write_handle function
        int     21H
        jnc     ct_40           ;if no error, continue

        push    ax              ;else, stabilise DOS
        mov     ah,19H          ;  with dummy call to function 19h,
        int     21H
        pop     ax
        mov     bl,10           ;setup string with error number
        div     bl
        add     ax,3030H
        mov     ret_code,ax
        $disp   ret_err_msg     ;  and display it
        jmp     ct_exit
ct_40:
        $disp   no_err_msg
ct_exit: mov    ah,4cH          ;DOS exit function
        int     21H
ce_test endp

;====================================================================
; Start of Critical Error handler code and data
;====================================================================
WIN_TOP  equ    10              ;these equate describe the popup
WIN_LEFT equ    20              ;window used by the error handler
WIN_HIGH equ    4
WIN_WIDE equ    40
WIN_ATTR equ    70H             ;reverse video screen attribute

devhdr_addr label dword         ;these values are saved upon entry
devhdr_off      dw ?
devhdr_seg      dw ?
save_ax         dw ?
save_di         dw ?

save_sp         dw ?            ;these are used in a CANCEL request
app_err         dw ?

response_msg    db "Retry or Cancel? (press R or C) ",0

crit_err proc   far
        mov     cs:save_sp,sp   ;save the stack position at start
        push    ax              ;save DOS's registers
        push    bx
        push    cx
```

```
        push    dx
        push    si
        push    di
        push    bp
        push    es
        push    ds

        push    cs
        pop     ds
        mov     devhdr_off,si   ;save address of the device header
        mov     devhdr_seg,bp
        mov     save_ax,ax      ;save err type & read/write bit flags
        mov     save_di,di      ;save error code

        and     di,00ffH        ;get critical error code
        add     di,19           ;convert to DOS error code
        mov     app_err,di      ;save in case we return directly to
                                ; the interrupted application
        call    save_scrn
        call    clr_window

        mov     ax,save_ax
        test    ah,80H          ;disk error ?
        jnz     ce_10           ; no, process character device error
        call    disk_err        ; yes, process disk error
        jmp     ce_20
ce_10:  call    char_err
ce_20:
        $set_csr <WIN_TOP+3>,<WIN_LEFT+1>
        $disp   response_msg ;display "Retry or Cancel" message

ce_30:  call    get_key
        or      al,32          ;force response to lowercase
        cmp     al,'c'         ;request to Cancel?
        je      ce_50          ; yes, go
        cmp     al,'r'         ;request to Retry?
        je      ce_40

        call    beep           ;else, invalid response
        jmp     ce_20          ;go back an wait for a vaild response

ce_40:  ;------------------- action taken on RETRY request
        call    restore_scrn ;leave screen as it was before error
        pop     ds             ;restore DOS registers
        pop     es
        pop     bp
        pop     si
        pop     di
        pop     dx
        pop     cx
        pop     bx
        pop     ax
        mov     al,1           ;set "Retry" return code
        iret                   ;and exit to DOS

ce_50:  ;--------------------- action taken on CANCEL request
        call    restore_scrn ;leave screen as it was before error
        mov     sp,cs:save_sp ;locally-saved regs are irrelevant
        pop     ax             ;and discard DOS IP
        pop     ax             ;              DOS CS
        pop     ax             ;              DOS flags

        pop     ax             ;restore application's registers
        pop     bx
        pop     cx
        pop     dx
        pop     si
        pop     di
        pop     bp
        pop     ds
        pop     es

        push    bp                  ;set the carry flag (on the stack)
        mov     bp,sp               ; so the application will
        or      word ptr [bp+6],1   ; notice that an error occurred
        pop     bp
        mov     ax,cs:app_err       ;and pass back a DOS error code
        iret
crit_err endp
```

```
;=================================================================
; Start of  code and data specific to character device errors
;=================================================================
gen_msg         db "General failure on ",0
paper_msg       db "Printer out of paper on ",0
read_msg        db "Error reading from ",0
write_msg       db "Error writing to ",0
device_msg      db "device '"
dev_name        db 9 dup(?)

char_err proc   near
         $set_csr <WIN_TOP+1>,<WIN_LEFT+1>

         mov    bx,save_di          ;fetch the error code
         mov    dx,offset gen_msg ; assume "general failure" error
         cmp    bl,9                ; is it a "paper out" error?
         jne    ch_10               ; no, go.
         mov    dx,offset paper_msg
ch_10:   cmp    bl,0aH              ; is it a "write fault" error?
         jne    ch_20               ; no, go.
         mov    dx,offset write_msg
ch_20:   cmp    bl,0bH              ; is it a "read fault" error?
         jne    ch_30               ; no, go.
         mov    dx,offset read_msg
ch_30:   $disp

         ;------- now find the name of the malfunctioning device
         push   ds
         lds    si,cs:devhdr_addr
         add    si,0aH          ;point to device name in driver header
         push   cs
         pop    es
         mov    di,offset dev_name  ;point to local buffer for name

         mov    cx,8        ; 8 characters max
ch_40:   lodsb              ; get a character
         cmp    al,' '      ;end of device name?
         je     ch_50       ; yes, go
         stosb              ; no, add to local string
         loop   ch_40       ; get next character
ch_50:
         pop    ds

         mov    al,"'"      ;close quote on the device name: 'PRN'
         stosb
         mov    al,0        ; and make string ASCIIZ
         stosb
         $disp  device_msg
         ret
char_err endp

;=================================================================
; Start of code and data specific to disk errors
;=================================================================
disk_read_msg   db "Disk read ",0
disk_write_msg  db "Disk write ",0
disk_err_msg    db "error on drive "
disk_id         db "A:",0

write_prot_msg  db "Disk is write-protected.",0
not_ready_msg   db "Drive door may be open.",0
bad_media_msg   db "The disk media seems to be flawed.",0
gen_fail_msg    db "General failure of the drive.",

disk_msg_tbl    dw write_prot_msg, gen_fail_msg, not_ready_msg ;1,2,3
                dw gen_fail_msg, bad_media_msg, gen_fail_msg   ;4,5,6
                dw bad_media_msg, bad_media_msg, bad_media_msg ;7,8,9
                dw gen_fail_msg, gen_fail_msg, gen_fail_msg    ;a,b,c
                dw gen_fail_msg                                ;d

disk_err proc   near
         $set_csr <WIN_TOP+1>,<WIN_LEFT+1>

         mov    ax,save_ax
         add    al,'A'
         mov    disk_id,al

         mov    dx,offset disk_read_msg ;assume read error
         test   ah,1
         jz     de_10
```

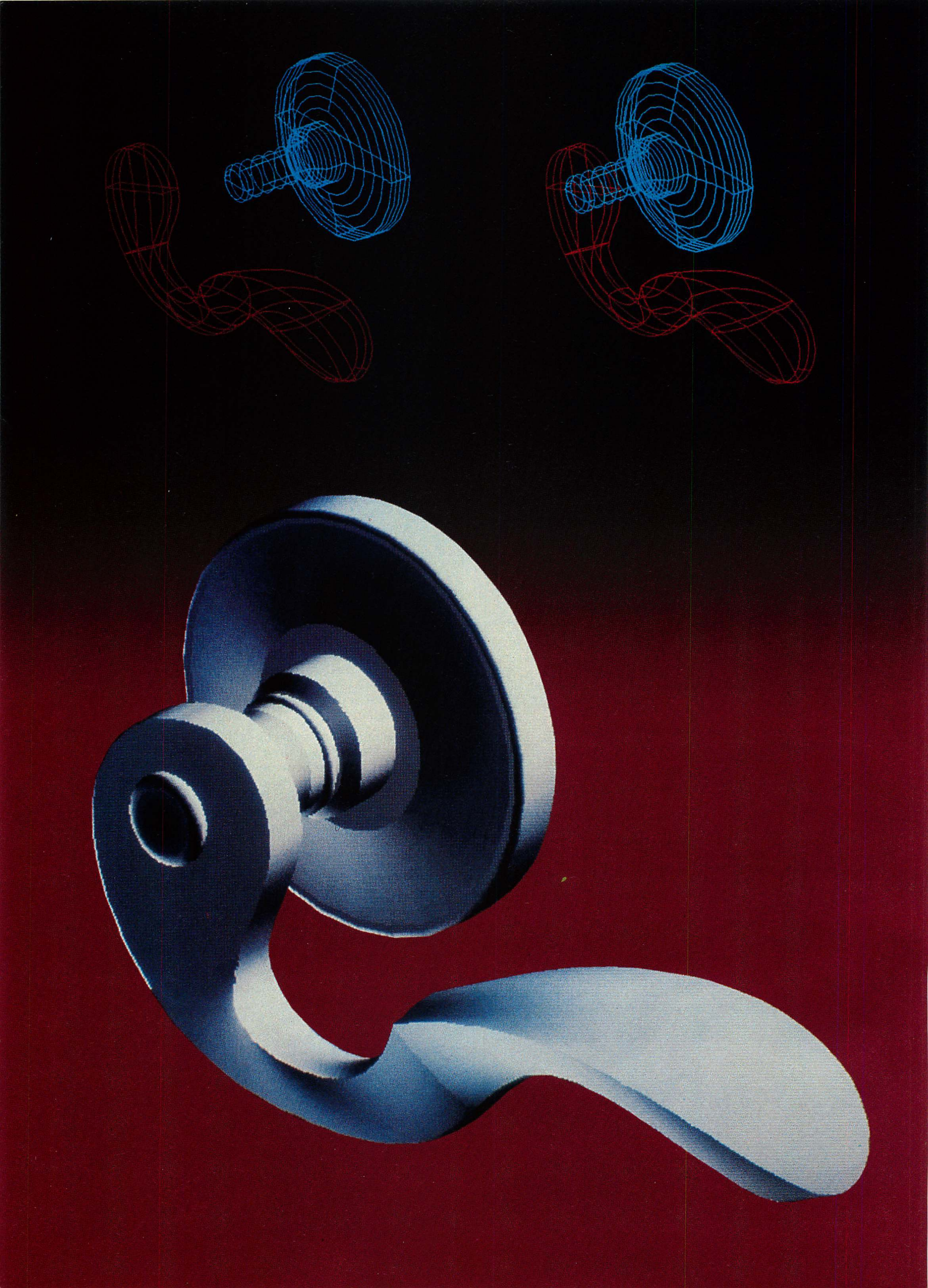


```
        mov     dx,offset disk_write_msg
de_10:  $disp               ;display "Disk Write " or "Disk Read "

        $disp   disk_err_msg ;display "error on drive x:"
        $set_csr <WIN_TOP+2>,<WIN_LEFT+1>

        mov     bx,save_di      ;look up which message to display
        mov     bh,0
        shl     bx,1            ;each address entry is 2 bytes long
        mov     dx,disk_msg_tbl[bx]
        $disp
        ret
disk_err endp
;=================================================================
; Start of general-purpose and library routines
;=================================================================

include ce_conio.asm            ;insert console I/O routines
;-----------------------------------------------------------------
; CLR_WINDOW
; This function clears the error message window.
; Window position, size, and display attributes are set by equates.
;-----------------------------------------------------------------
clr_window proc  near
        mov     ch,WIN_TOP
        mov     cl,WIN_LEFT
        mov     dh,WIN_TOP + WIN_HIGH
        mov     dl,WIN_LEFT + WIN_WIDE
        mov     bh,WIN_ATTR
        mov     al,0            ; AL=0 means clear window
        mov     ah,6            ;BIOS scroll_window service
        int     10H
        ret
clr_window endp

;-----------------------------------------------------------------
; SAVE_SCRN
; This function save's the application's screen
; and cursor position.  Doesn't work for graphics-mode screens
;-----------------------------------------------------------------
save_scrn proc  near
        push    ds
        push    es

        mov     bh,0            ;assume video page 0
        mov     ah,3
        int     10H             ;get cursor position
        mov     cs:save_csr,dx  ;save for restore_scrn function

        int     11H             ;locate video memory segment
        mov     bx,0b800H       ;assume color card
        and     ax,30H
        cmp     ax,30H
        jne     sc_10
        mov     bx,0b000H       ;must be mono card
sc_10:
        mov     cs:scrn_seg,bx  ;save for restore_scrn function

        mov     ds,bx           ;source is video memory
        mov     si,0
        push    cs              ;destination is local scrn buffer
        pop     es
        mov     di,offset scrn_buf
        mov     cx,2000         ;count of words on entire screen
        rep movsw

        pop     es
        pop     ds
        ret
save_scrn endp
;-----------------------------------------------------------------
; RESTORE_SCRN
; this function restore's the application's screen
; and cursor position
;-----------------------------------------------------------------
restore_scrn proc near
        push    ds
        push    es

        mov     dx,cs:save_csr  ;fetch application's cursor pos
```

```
        mov     ah,2
        mov     bh,0                ;assume video page 0
        int     10H                 ;set cursor position

        push    cs                  ;source is local screen storage
        pop     ds
        mov     si,offset scrn_buf

        mov     es,cs:scrn_seg      ;destination is video memory
        mov     di,0
        mov     cx,2000             ;count of words on entire screen
        rep movsw

        pop     es
        pop     ds
        ret
restore_scrn endp

scrn_seg dw  ?                  ;used by save_scrn and restore_scrn
save_csr dw  ?
scrn_buf label   word           ;local screen storage begins here

code_seg ends
        end     ce_test
```

LISTING 3: CE_CONIO.ASM

```
;=================================================================
; General-purpose console I/O routines
;   For Break Handler (BRK_TEST) & Critical Error Handler (CE_TEST)
;=================================================================

;-----------------------------------------------------------------
; GET_KEY
; Clears the keyboard buffer, waits for a key and returns it in AL.
; Returns -(key) for extended ASCII keystrokes
;-----------------------------------------------------------------
get_key proc    near
        mov     ah,0cH          ;clear kb buffer
        mov     al,07H          ;console input function
        int     21H

        cmp     al,0            ;extended ASCII?
        jne     gk_exit

        mov     ah,07H          ;get the extended ASCII code
        int     21H
        neg     al
gk_exit: ret
get_key endp

;-----------------------------------------------------------------
; DISP_MSG
; This function displays an ASCIIZ message at the current cursor pos
; DS:DX = address of start of the string
; Uses BIOS services only.
;-----------------------------------------------------------------
disp_msg proc   near
        mov     si,dx
dm_10:  lodsb
        cmp     al,0            ;done with the string?
        je      dm_20           ; yes, exit
        mov     bh,0            ; no, select video page 0
        mov     ah,0eH          ;     use write_tty service
        int     10H             ;     to display a character
        jmp     dm_10           ; loop back for next character
dm_20:
        ret
disp_msg endp

;-----------------------------------------------------------------
; BEEP
; sounds the bell by printing an ASCII 07H via BIOS write_tty service
;-----------------------------------------------------------------
beep    proc    near
        mov     al,07H
        mov     ah,0eH     ;BIOS write_tty service
        int     10H
        ret
beep    endp
```



A CADD Workstation

Computervision's Personal Designer is an adaptation for the IBM PC of the company's minicomputer-based CADD system.

VICTOR E. WRIGHT

The rapid growth of microcomputer-based CAD has affected the traditional minicomputer workstation market more than other micro applications have upset their mainframe and minicomputer counterparts. Before the advent of microcomputer CAD, and for a long time after, CADD (computer-aided design and drafting) vendors enjoyed a comfortable market for their workstations. CADD was a high-profit industry, with room for new entrants.

Without a doubt, microcomputer CAD has affected the sales of the large systems. Some of those large vendors have witnessed dwindling profits; others have all but disappeared. Many large vendors are just beginning to realize the potential of the personal computer and the reality of the demand for microcomputer-based CADD systems.

Computervision is one such CADD powerhouse that has entered the microcomputer market: the Personal Designer package (a subset of its Computer Automated Design and Drafting System, or CADDS) is available through the firm's Personal Systems Business Unit division. CADDS, developed over a period of 15 years, has some 2,000 installations. Computervision targets both existing installations, and new users for sales of Personal Designer systems. Typically, Personal Designer is sold as a turnkey system, which includes the host PC/AT, Computervision's version of a Vermont Microsystem, Inc. 8820 graphics controller (compatible with an IBM Professional Graphics Controller), a monitor, a Kurta series 1 or 2 digitizer, and software. However, the software can be purchased separately. For this review, the Personal Designer elements were tested on a 6-MHz AT, and on a Heathkit H-248 (an 8-MHz AT compatible), using Computervision's Advanced Graphics Board (a VMI 8820 with custom firmware) and an NEC Multisync monitor as the graphics display system.

Personal Designer is a system of programs. The basic package is the microCADDS Geometric Construction and Detailing program—GCD. The basic program can be extended with a number of options. Surface modeling is provided with the addition of the Surfaces program, finite element modeling with the Personal Designer Finite Element Modeler package, finite element analysis with the MSC/pal 2 package. Macro extensions can be added with the User Programming Language (UPL) module, discussed later. Other similar systems available from Personal Systems Business Unit include Personal Machinist and Personal Architect.

This is a true three-dimensional production drafting system, with a full set of design extensions. Models are wire-frame models, but the program generates surfaces, if the Surfaces module is installed. The generated surfaces can be shaded to produce highlighted three-dimensional models of the quality associated with much larger systems.

The Personal Designer workstation can operate as a stand-alone unit, or it can be networked with a larger Computervision system for file exchange, or it can be connected directly to a Computervision host machine.

As configured on the distribution disks, the Personal Designer display consists of a graphics window, a com-

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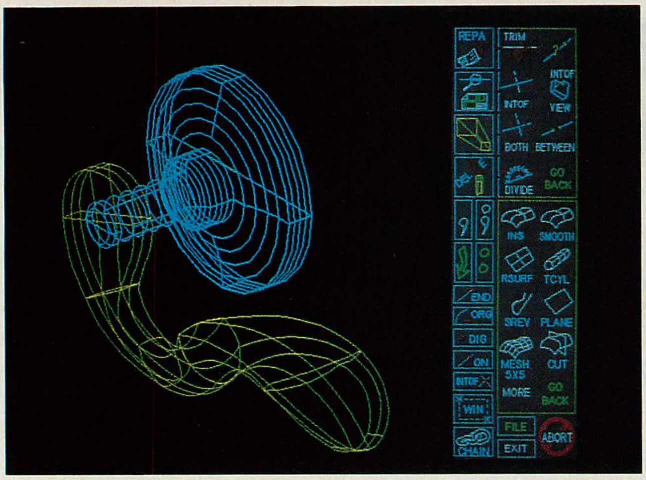
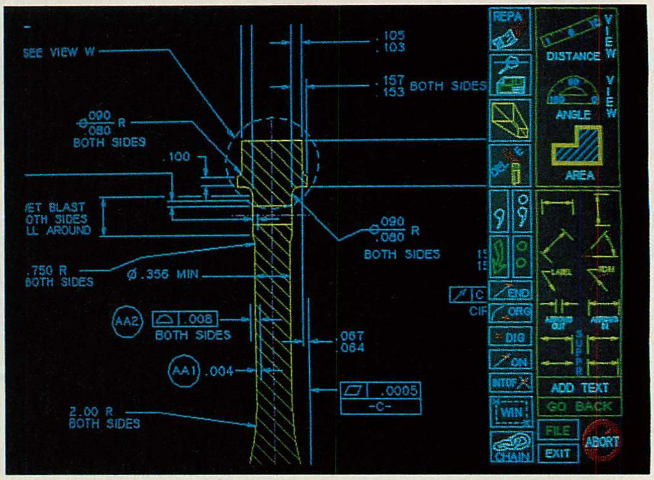
PHOTO 1: *Sample Screen with Menu*



A Personal Designer wire-frame model is displayed with one of the menus. The model consists of curves and surfaces.

PHOTO 2: *Alternative Screen Menu*



The dimensioning facility is not associative. As the part is altered, the dimensions are not updated automatically.

mand/prompt area across the top of the screen called the scrolling region, and a menu area on the right side (see photo 1). The program can be configured to add a coordinate display area that tracks the cursor and a message area along the bottom of the display.

The entire screen has a "graphics" look; that is, the hardware text font seen in the text windows of some CAD programs is not used here. The text used for command prompts and echoes is the same block font used when text is inserted in a drawing using the default font. Similarly, the screen menu consists of icons, rather than a list of commands. In fact, the screen menu is a drawing that can be edited.

The command area can be resized at any time, by dragging a window or by specifying the number of lines of text to be displayed. The command window can be sized to fill the screen or to display only a single line of text.

The menu can be turned off and on with the pointing device. The menu includes an icon for turning itself off. When the menu is off, a single icon appears in the scrolling region; selecting it turns the menu back on. The coordinate display is set to off by a flag in the configuration file. No command is provided to toggle it off and on.

Personal Designer is typical of CAD systems in that it operates in a loop. A command prompt, >>, is displayed in the scrolling region. The user enters a command that specifies what action is to occur, and where or how it is to occur. Commands to be entered can be typed in from the keyboard, selected from the screen menu, or selected from a digitizer overlay.

Most microcomputer-based CAD systems accept a command, then prompt the user for the parameters that are required to execute the command. A Personal Designer command is divided into two sections, the command section and the **getdata** section, separated by a delimiter, which is a colon(:). These two sections correspond to the commands and parameters of other systems, but are somewhat more complex. A command typically consists of a verb and a noun; optional modifiers can be used to select variations of a command, to control the display of the entity named, or to specify data that otherwise would have to be entered graphically. The **getdata** section consists of the prompts by the program, the graphic input, and optional references and masks. In addition, several **getdata** commands can be entered while another command is in progress. These **getdata** commands typically duplicate commands that can be entered directly at the command prompt, providing a method for nesting commands.

If commands are typed in from the keyboard, the complex syntax requires more typing than is necessary with some other systems. By the same token, the complex syntax allows the entry of more precise commands. The use of verbs, nouns, and references often provides several ways to construct or modify a given entity. (References correspond to object snap modes in other systems of this type, and are discussed later in the article.) Masks provide a means of restricting the type of entities to which a command is applied.

Entity masks are not used as commonly in micro CAD systems as object snap modes are. As implemented in Personal Designer, they allow the user to specify the types of entities to be included in or excluded from a selection group. For example, the user can move all of the text in an area without disturbing the surrounding lines, circles, arcs, and surfaces simply by including the TEXT mask in the **getdata** portion of a MOV ENT command, and then windowing the entire area. Entity masks can be inclusive or exclusive. Continuing with the example, everything but the text in the same area can be moved by including the XTEXT mask in the **getdata** portion of the command.

The entity masks are included to mask all entities, angular dimensions, arcs and circles, entities of specified colors, figures, labels, linear dimensions, lines, points, radial dimensions, line strings, text, and cross-hatching in the basic version. If the Surfaces module is included in the system, additional entity masks are provided for the various types of surfaces.

The icons in the screen menu and the digitizer menu invoke commands complete with verbs, nouns, delimiters, references, and in some cases, masks. The menus are more easily learned than is the complete command syntax, but to realize the full potential of the program, a user really must learn the syntax. (See photo 2 for an example of an alternative menu.) In many cases, the order in which command elements are entered is not critical—the user is learning concepts, not rigid sequences. Once learned, this command syntax provides a more concise method of specifying complex actions than a simpler syntax can offer.

THE DRAWING SPACE

Personal Designer's drawing world is on the order of 7.0 by 10^8 units along each of the three axes. This generous size drawing world certainly will be adequate for most drafting assignments. This limit is imposed intentionally to prevent problems associated with attempting to process zoom commands with out-of-range parameters. The limit was chosen to accommodate the type of design for which the program is used. (The author of the program is an aircraft designer.) The Personal Designer's drawing world is truly three dimensional. Any entity can be positioned arbitrarily within the drawing space.

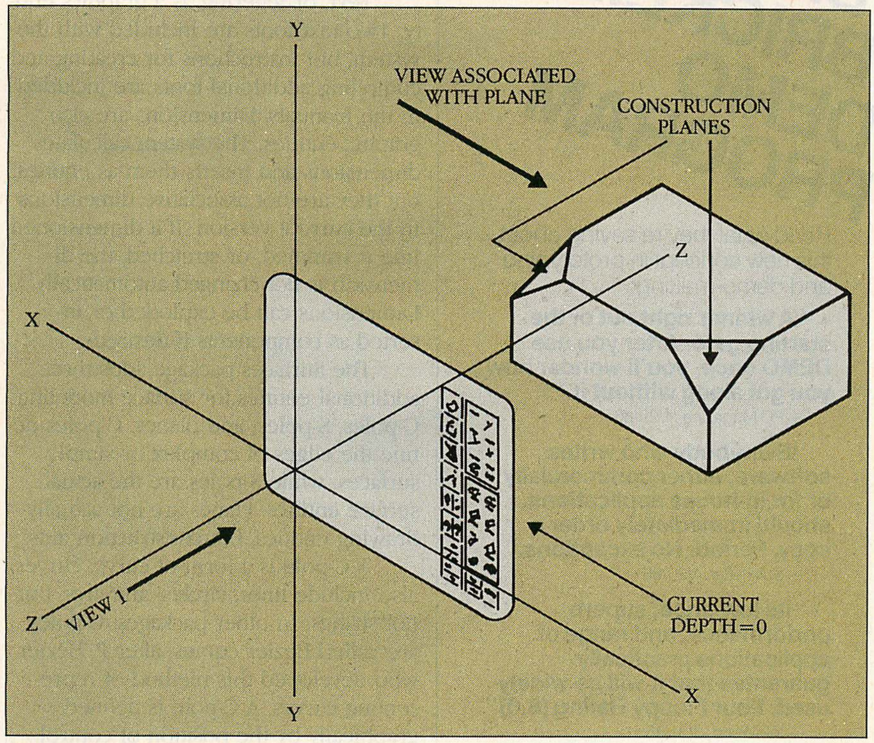
The screen is a window into the system's drawing world (see figure 1). This window initially is positioned so that the *X* and *Y* axes are in the plane of the screen, and the *Z* axis is normal to the screen. Entities entered graphically are placed in the *X–Y* plane, with an elevation of 0. Entities can be entered at other locations by specifying the three coordinates on the command line instead of entering them graphically, or by repositioning the coordinate system relative to the screen.

Changing the current view repositions the coordinate system. Six predefined views are available, which are numbered 1 through 6, and correspond to the top, front, right, bottom, left, and rear views of traditional orthographic drawings. Changing the view does not alter the current elevation, only the orientation of the coordinate system. The current elevation can be changed using the SELECT DEPTH command, which determines the distance of the current viewing plane from the origin of the coordinate system. The depth that is set with the SELECT command applies to all views, but both positive and negative depths can be set. Thus, two opposite faces of a cube centered on the origin can be drawn in the same view by selecting a positive and then a negative depth, or by selecting a positive or a negative depth, and then selecting two opposite views in turn.

With the use of references, entities can be entered with little attention to the current depth. For example, a line can be drawn between the ends of two other lines by using the END reference, regardless of view or current depth.

When attaching new entities to entities that were constructed in the orthographic views, it is often advisable to work in an inclined view, to insure that the correct entity or reference is selected. In the orthographic views, one entity is likely to be masked by another.

FIGURE 1: *Personal Designer Drawing World*



The Personal Designer drawing world is a true three-dimensional space. As many as 256 different layers can be specified; these can be views or construction planes.

As many as 32,000 views can be defined, including the six predefined views that were listed above. Defining a new view is interactive; the model space is rotated about the three axes until the view is suitable, and then a view number is assigned. After that the view can be recalled by number.

A second method of defining views is useful when a model has been partially constructed. A view can be defined by selecting three entity references, such as the ends of the edges of a surface that is inclined in the current view. Personal Designer then rotates the drawing space so that the selected plane is parallel to the screen. Defining a view in this manner leaves the current elevation unchanged; the plane that is used to define the view may or may not lie at the current elevation.

The user can define a construction plane, which provides a local coordinate system. A construction plane, called CPLANE by Computervision, is defined by digitizing entity references, such as intersections, origins, and ends. The first point selected is the construction plane's origin; the second defines the *X* axis; and the third defines the *Y* axis. A construction plane has an associated view, although not every view need have an associated construction plane. Up to 32,000 construction planes can be defined, but the numbers assigned are in the same series as the views. The allowed views include those associated with construction planes.

Once defined, a construction plane can be activated with the SELECT command, and geometry can be entered directly on the plane, regardless of the current elevation. A construction plane can be activated without restoring the associated view, which can lead to unexpected results while learning to use the system. If a plane is activated, and the user wishes to draw in a true view, the associated view should be restored as well. However, the ability to activate a construction plane without restoring the associated view allows the user to place geometry on an inclined plane while referring to another plane in true view. This facility proves to be an extremely useful one. Because Personal Designer models are wire-frame models, it is easy to become disoriented and construction planes help ensure that geometry is placed as intended.

In Computervision terminology, a graphic entity is anything that can be inserted into a drawing. The most fundamental entities are simple entities—lines, circles, arcs, and points. A string is a compound entity, consisting of several simple entities that are connected end to end. As far as the user is con-

cerned, however, a compound entity is still a single graphic entity.

Text, or lettering, is a graphics entity. Two text fonts are included with the system, but instructions for creating and compiling additional fonts are included in the manuals. Dimensions are also graphic entities. The system calculates dimensions and inserts them as entities, but they are not associative dimensions in the current version. If a dimensioned line is trimmed, or stretched, the dimension is not changed automatically. Dimensions can be exploded or inserted as components if desired.

The Surfaces package adds three additional entities for surface modeling: C-poles, S-poles, and planes. C-poles define the edges of complex or simple surfaces, while S-poles are the actual surface entities. Planes are not actually drawing entities, but construction aids.

A C-pole is a form of curve; curves also include lines, circles, and arcs, but not strings. In other packages, C-poles are called Bezier curves, after P. Bezier who developed this method of representing curves. A C-pole is defined graphically by the position of control points called poles, which also form the vertices of the controlling polygon. The position of each pole is represented in the drawing database as a coefficient in a polynomial equation, but C-poles are entered graphically by picking the locations of the control points. The program displays the controlling polygon as the C-pole is entered. The controlling polygon usually disappears after the next screen repaint, but it can be redisplayed if desired.

Personal Designer's one surface entity, an S-pole, is similar to a C-pole, in that its shape is controlled by poles and a controlling polygon. The S-Pole can be created by digitizing the poles directly; it also can be created by digitizing four curves bounding a region. An S-pole can be flat, curved in one direction only, or arbitrarily curved.

In Computervision terminology, a drawing is a part. One part can be inserted into another part; that is, a drawing can be inserted into another drawing. A part can be inserted either as a part or as a figure. These two terms correspond to block or symbol definitions and block or symbol references. These features allow the user to create a comprehensive symbol library.

DRAWING AIDS

Personal Designer provides most of the expected drawing aids, a few not commonly found in microcomputer systems and a few with obvious weaknesses.

The coordinate display tracks the cursor location and is one of Personal Designer's weaker features. The first drawback is that the coordinate display must be enabled or disabled by changing a flag in the configuration file.

The second is that the coordinate display reflects the actual location of the cursor, regardless of whether or not the program is set to snap to a grid. The grid, a grid of dots, indicates the locations to which picks will snap. A separate command to set an invisible snap grid is not available.

The grid can be turned on and off with a command verb, noun, and modifier, or with a **getdata** command. In other words, it can be disabled and enabled within other commands by typing the **getdata** commands, GOFF and GON. Turning the grid off does not remove it from the screen, so its presence does not indicate whether or not the next pick will snap to the grid. A screen repaint must be executed to remove the grid once it is turned off.

An undesirable feature of Personal Designer is that the grid does not rotate with the coordinate system. If the view is changed to an isometric view, the grid does not become an isometric grid. It remains a rectangular grid, and does not line up with the model.

When the grid is on, it is displayed, regardless of the current zoom ratio. To avoid obscuring the drawing with a too-closely spaced grid, the program scales the grid when the zoom ratio is too high. Each time the screen is repainted, the scaling factor is displayed, if it is greater than 1, with an annoying beep. Iterating toward a new view is a noisy process if the grid is on. The grid can be easily repositioned and it can be set to arbitrary aspect ratios.

Instead of an ORTHO mode that can be turned on and off, Personal Designer provides VER and HOR **getdata** commands. Both the screen and digitizer menus provide icons for vertical and horizontal lines; the icons include VER and HOR modifiers in the command, before the delimiter.

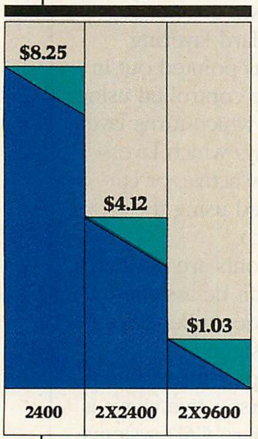
In fact, the command format is a drawing aid. The **command : getdata** format allows commands to be tailored to the task at hand (see figure 2). The ability to enter **getdata** commands allows commands to be nested, in effect. The active command can be repeated by signalling the program to restart the **getdata** portion of the command without terminating and reentering the command portion.

The manual describes the use of construction lines in the context of

Is Your Modem Holding You Up?

Face it, if your modem is too slow you're spending too much time waiting and too much money on telephone charges. If your modem is faster than you need, you bought too much modem.

In either case, you're being held up!



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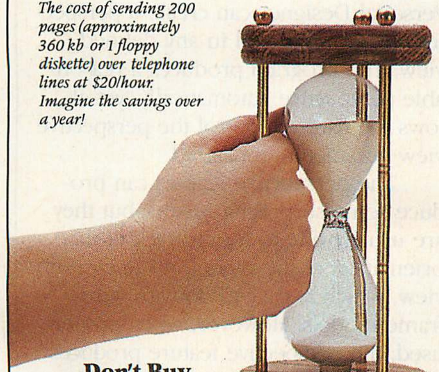

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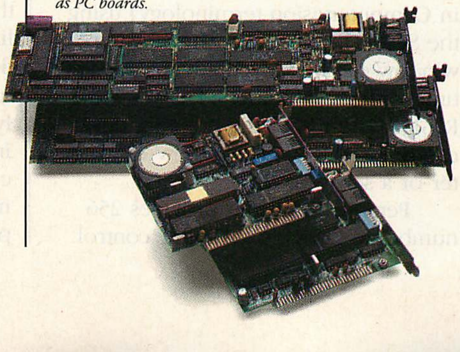

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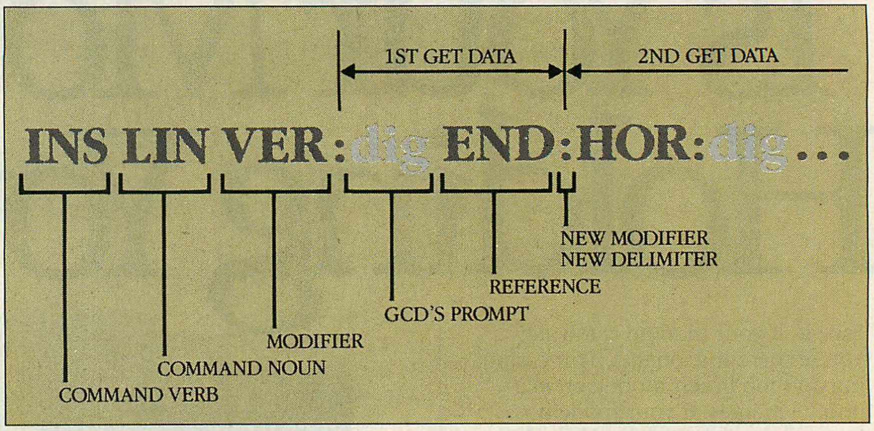
FIGURE 2: *Diagram of Command Structure*



The syntax consists of a command section and a getdata section, separated by a colon. A command typically consists of a verb and a noun, with optional modifiers.

drawing aids. Personal Designer, however, does not provide a distinct entity type for construction lines. Instead, the manual advises the user to set up a layer for construction lines and then to use a different line font.

Personal Designer includes the expected display controls for changing the scale of the display, panning the display, and controlling the visibility of groups of entities. The ZOOM command allows the display to be enlarged or reduced, relative to the current display or to the original drawing display. A command modifier fills the screen with the current drawing extents, and another modifier allows specification of the display with a zoom window. The previous display cannot be recalled, but the modifiers UP and DOWN allow enlarging and reducing the display by the same factor: ZOOM UP 2 and ZOOM DOWN 2 produce complementary effects.

All of the commands can be nested in other ones by entering their corresponding **getdata** commands; for example, ZWIN executes a zoom window and ZALL executes zoom all. The operation of **getdata** zoom commands is unnerving at first; if the end of a line is picked while zoomed in, and ZALL is entered, the rubberband cursor does not remain attached to the original pick. However, the line appears correctly when the second point is picked.

The drawing is panned (or scrolled in Computervision terminology) using the SCROLL command. The viewing window can be moved a half-screen at a time with the modifiers, DOWN, LEFT, RIGHT, and UP, or the pointing device can be used to digitize a new view center or a scroll vector.

Personal Designer provides 256 numbered layers for visibility control. English names or aliases are not supported, so that a standard layering scheme is advisable, as pointed out in the manual. Layers are controlled using the ECHO command, which turns layers on and off, and displays which layers contain entities. A new active, or current, layer is designated using the SELECT command verb.

Colors and line fonts are not tied to layers. Any entity can be assigned a color and line font independently of the layer to which it is assigned.

The ability to display three-dimensional drawings in perspective views is missing from most micro CAD systems. Personal Designer can create a perspective view of a model in any defined view. The program produces a reasonable perspective automatically, yet allows the user to control the perspective view parameters if desired.

The perspective feature can produce some surprising results, but they are usually due to losing track of the orientation of the model in the current view, which is easy to do with wireframe models. However, when properly used, the perspective feature produces pleasing perspective views as quickly as the screen is repainted.

THE CREATIVE PROCESS

Drawings and models are created by inserting entities, which are named with the noun in the command; for example, the sequence **INS LIN:getdata** inserts a line, or a series of line segments. Modifiers then can be entered following the noun to specify the entity more precisely; the sequence **INS LIN VER:getdata** inserts a vertical line (vertical in the current view, not necessarily in the model space). Figure 2 gives an example of the command structure.

A series of similar entities can be inserted by repeating only the **getdata** section of the command. This is accomplished by entering a colon, an optional modifier, and another colon.

It should be noted that, although Personal Designer is a full three-dimensional system, no three-dimensional primitive objects are available. The set of entities created with the INSERT command does not include cubes and spheres. Three-dimensional models are created with curves (including lines) and/or surfaces. Although it would be a waste of the program, Personal Designer can be used strictly as a two-dimensional drafting package.

Creating a three-dimensional model from two-dimensional primitives requires a fair amount of navigation of the drawing space, by changing views, the current elevation, and the current construction plane. Personal Designer provides only minimal information on the screen, aside from the model itself. The coordinate display is available, and the construction plane coordinate system axes can be echoed if desired. Additional information is available from the system via the LIST command, however, the designer must learn to keep track of the orientation of the model views in the drawing space.

The references points available when drawing (see figure 3) correspond to object snap modes of other systems. Personal Designer's references include chains of entities connected end to end, temporary origins, digitized points, ends of entities, groups of entities, intersections of entities, apparent intersections, the last coordinate entered, index pointers, the axes of the model, origins of entities (centers and midpoints), points, the axes of the screen coordinate system, and windows.

Construction lines are also essential to the creation of complex models. Although a model can be constructed simply by entering coordinate data from the keyboard, this requires that a substantial amount of work be done before sitting down at the terminal. It is easier to rough out an object with construction lines, then use the construction line references for the creation of the model. Often it is easier to insert an entity into an easily established location, and then move it, than to create it in the desired location.

Many model components can be created by first drawing a cross section, then projecting the cross section along an axis, using the PROJ command. One or more entities are selected, then the axis of projection is entered. The axis can be entered by typing the coordinates in at the keyboard, by picking two points graphically, or by picking references in the existing geometry.

Personal Designer also includes a complete selection of editing commands. Entities can be deleted, moved, trimmed, stretched, mirrored, and rotated. A CHANGE verb is provided to change colors, fonts, text attributes, string attributes, and entity groups.

If symbol libraries are considered *useful* in two-dimensional drafting programs, they are *essential* to Personal Designer. Creating three-dimensional models is much more complicated and time-consuming than creating two-dimensional drawings. Thus, it is necessary to maintain libraries of parts for use in assembly drawings.

A part is created with the use of the CONSTRUCT command verb, which requests a filing name, selection of the component entities, and an origin. Parts are automatically written to disk files, and the original components are not erased from the drawing.

Inserting a part into a Personal Designer model is accomplished using the INSERT command verb. This operation can be as simple as in a typical two-dimensional part or considerably more involved. If the correct view and elevation is selected before the part is inserted, and the scale of the part is correct, it may be sufficient to specify the insertion point. If not, Personal Designer permits the user to specify the orientation of the part: the view of the part being inserted and the view of the model into which it is inserted, the angle of the inserted part's X axis to the X axis of the current view or construction plane, a new X axis for the inserted part, layering specifications, grouping specifications, and scale along each of the three axes, X, Y, and Z.

Parts can be inserted as parts or as figures. If a part is inserted as a part, its elements can be edited; once inserted, the part is no longer a single entity.

If inserted as a figure, a part remains a single entity and cannot be edited. An additional feature is that figures are updated in all drawings when the original is modified. If a part is inserted as a figure, it can still be reduced to simpler components, which can then be edited. The EXPLODE command works on figures, strings, arcs, crosshatching, and dimensions.

FITTING IN THE DETAIL

Detailing is the process of turning the design drawing or model into a document that others can use. Many design-

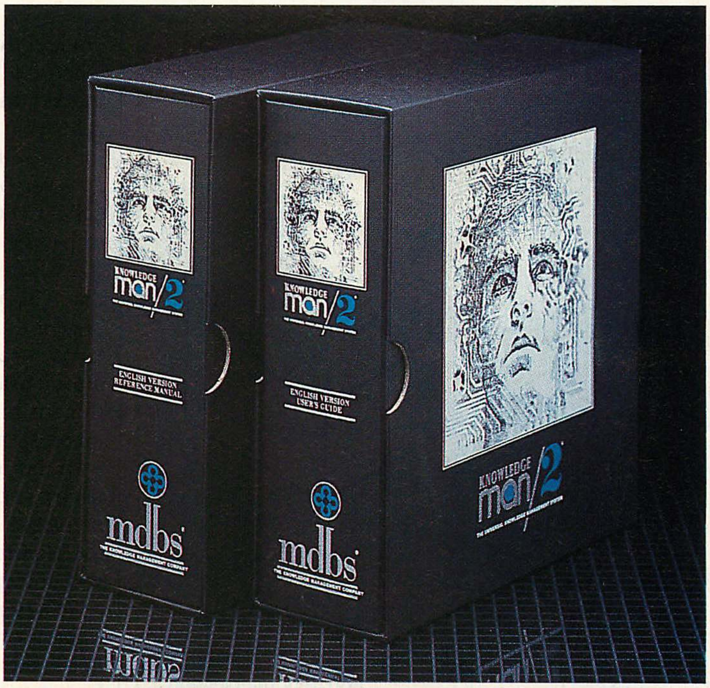


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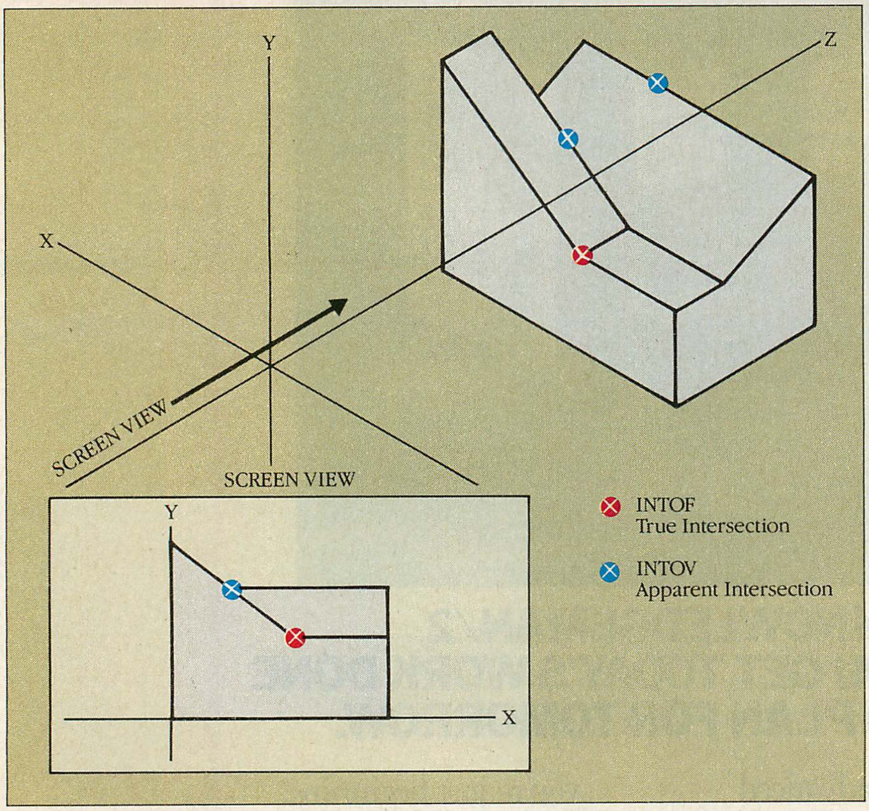
FIGURE 3: *Sample References*



References correspond to object snap modes. An apparent intersection moves depending on the current angle of view; the actual intersection remains constant.

ers feel that the design work is done when the first sketch is complete, and, indeed, many engineering departments rely upon detailers to turn the sketch into working drawings.

Personal Designer provides an excellent automatic dimensioning facility to handle detailing. The program requests the two entities or references that will be dimensioned, and the location of the dimension line. It then calculates the dimension value and inserts a dimension entity, which includes the dimension text, the witness lines, the dimension line, and the arrowheads. As with the other commands, modifiers are used to specify the appearance of dimensions. The user has control over the alignment of the dimension line; text angle, height, and width; size and orientation of arrowheads; precision of dimension values; display of witness lines; and visibility of dimensions. Similar control is available over both linear, angular, radial, and point (*X, Y, Z* coordinate) dimensions.

By default, dimensions are displayed only in the view in which they are inserted. Modifiers are provided to toggle this feature. Visibility is tied to individual dimensions. Thus, some dimensions can be displayed in all views and others in specific views as desired.

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Personal Designer's cross-hatching feature is simplistic. Cross-hatching patterns consist of parallel lines; the user can specify the line spacing and the angle. Unlike most CAD packages, cross-hatching can be inserted in areas bounded by entities that do not meet precisely; a tolerance for the gap can be specified in the command. Hatching is visible in all views, a feature that can be used to aid in maintaining orientation. The ability to cross-hatch in areas that are not completely bounded is convenient, but the lack of variation in cross-hatching is especially limiting for mechanical designers and is a design restriction that should not be present in a package of this complexity.

The text handling available in Personal Designer is as powerful as cross-hatching is weak. Several commands are devoted to text. Labels are text entities with leaders. The text entry can consist of as many as 1,000 characters, and it can contain embedded control characters. The angle, height, width, and line spacing of the text can be specified. The leader of a label must begin on an entity, as the label is attached to the entity. However, the entity can be deleted without deleting the attached labels.

Notes or other text that are not attached to specific entities are entered as TEXT. Using control characters, text strings can be split into lines, displayed in an alternate font, boxed, changed in height, superscripted, and subscripted.

For standard notes, specifications on drawings, or simply convenience, the INS TFILE command is an invaluable tool. This command reads into the drawing a text file that has been created with a text editor or word processor in a nondocument mode. Each line in the disk file is inserted as a single text string, as would be entered otherwise with the INSERT TEXT command. Therefore, each line in the file becomes a separate entity in the drawing.

The INS TFILE command does not allow the use of modifiers as does the INSERT TEXT command. Instead, the SELECT TEXT command must be used to predetermine the text characteristics, if they are to differ from the defaults. SELECT TEXT can also be used to define text characteristics before using INSERT TEXT. All text characteristics and the text itself can be edited using the CHANGE TEXT command.

The property feature provides the user with a mechanism for producing documents such as bills of materials from drawings, more or less automatically, and for producing schedules on drawings. Properties (nongraphic attributes) can be attached to entities, both figures and primitives.

Properties are not defined as part of the entity definition, as are attributes in some systems, but they are attached to entities on an individual basis. Since properties can be attached to primitives, one-of-a-kind objects can be placed in a bill of materials without having to first turn them into symbols.

A property has a name and a value. The value can be text or numeric with text as the default. A single invocation of the INS PROP command inserts one name value pair, one or more times. An arbitrary number of properties can be attached to an entity.

An external utility, EXTRACT, extracts properties from a drawing file. This utility scans the drawing database and creates a text file with entry for each property extracted. If the property value contains more than one line, the entry in the text file will contain a corresponding number of lines.

The property feature is intended for use with a text editor or database management program. However, if a property value contains more than one field in terms of content, it is still treated as a single field by the EXTRACT utility. Using a text editor to transform the extract file into a document is a relatively straightforward procedure. Importing the same file into a database management system will require more effort, unless each name value pair contains only a single field.

SURFACE MODELING

As mentioned previously, the Surfaces module is an optional addition to the GCD package that includes both entities and commands. GCD supports the creation of wire-frame models; the drawing database contains entities that represent the edges of surfaces. In GCD, no information about the surfaces themselves is recorded if only the basic features are used. Thus, wire frame models are inherently transparent.

The Surfaces package thus adds the capability of recording information about the surfaces themselves. With this program option installed, a Personal Designer drawing database can contain information about the boundaries of a surface and the shape of the surface between those boundaries.

Surfaces adds only a single surface entity, the S-pole; however, it adds a number of commands for the creation and manipulation of S-poles. Two basic methods of creating surfaces are provided—inserting and smoothing. To INSERT a surface requires direct input

of the controlling polygon; to SMOOTH a surface means that the system infers the controlling polygon from existing contiguous boundary curves.

Several methods are available for generating surfaces. Using a circle as an example, a sphere can be generated by rotating the circle around an axis. Alternatively, a cylinder can be generated by projecting the circle along a vector. Drawing straight lines between corresponding points of two curves is yet another way to generate a surface.

The general surface is bounded by curves on four sides and is curved in both directions. It can be created directly or inferred from existing curves. Although the shape of single surface patches is limited, an arbitrary number of them can be connected to create arbitrarily complex surfaces.

Surface models can be created without first creating a wire-frame model—but it requires a great deal of planning and thought. Most designers are well-advised to build a wire-frame model and then add the skin. A workable approach for most models is to create a wire-frame model, add C-poles for contour lines, smooth or insert S-poles between the C-poles, and finally tune the surfaces by repositioning the poles of the surfaces.

Although the basic GCD package does not include construction lines explicitly, Surfaces includes a useful construction tool—planes. Planes are infinite flat surfaces in the drawing database. They are displayed as small squares and should be placed on special layers, because they are not really intended for display in a final drawing.

Planes are used to control the construction of other entities. A plane can terminate the projection of a tabulated cylinder or construct a tabulated cylinder between two planes. Similarly, planes can trim curves or establish the plane of a fillet between two nonintersecting curves. Planes can also be used to display cross sections of a surface, or surface contours at specified intervals. Planes can be inserted for this purpose or generated along the primary axes or along a curve.

If only the intersection of two surfaces is required, it can be displayed and placed in the database as a string. The intersection can be placed on the current layer, or on a specified layer.

While in the GCD program, surface models are displayed as wire-frame models. By default, only the surface boundaries are displayed, but intermediate curves can be specified. These curves are not part of the surface model, but are provided to assist in visualization. The drawing database does contain the mathematical description of each surface in the model.

In most cases, the objective of creating a surface model—and the justification for the time that such an operation requires—is the display of a shaded picture. This process is the least interactive of all that can be done with Personal Designer. The first step in creating a shaded picture is to create a complete surface model. Only surfaces will appear in the final shaded picture; the wire-frame geometry will not appear. In addition, the colors in the shaded picture are determined by the colors in the surface model.

The surface model then must be displayed in the desired view, while it is in GCD. An arbitrary number of pictures can be created from one model by selecting various views, turning layers on and off, and changing colors. Each view that is to become a shaded picture must be saved in a surface model data file, using PUT SHADE. This command allows several data files to be created within a single session.

The actual shaded pictures are created using an external program, SHADE. This program processes the data file and produces a picture file, which is in turn displayed using the DISPLAY program. The SHADE program enables fine tuning; it allows for the specification of the quality of the shaded picture, the direction of the light source used to determine shading, the background color, and the type of picture, either faceted or smooth.

The surfaces of a faceted display are composed of flat tiles, while the surfaces of a smooth display appear to be continuous. If the smooth display is selected, transparency and reflection also can be controlled. Smooth displays take longer to produce than do faceted displays—sufficiently longer that it is often worth checking a picture by first producing a faceted display as a preview of the final smooth display.

The manual does not point out that surfaces in parts inserted as figures are not displayed in the shaded picture. Surfaces in parts inserted as parts, however, are displayed in the shaded picture. Displaying surfaces in figures would have added considerable complexity to the Surfaces program. The figures facility is not likely to be used in surface modeling and can be accommodated by the use of parts instead of figures; therefore, it can be argued that displaying figures with surfaces would not be worthwhile.

SPEAKING THE LANGUAGE

A user programming language is a prerequisite to using CADD in referring to an interactive graphics program. It is the user programming language, such as UPL (which is included with Personal Designer) that allows users and third-party developers to customize a package so that designers can use it in the language of their discipline.

Computervision's UPL is a block structured language that resembles Pascal somewhat. A UPL program consists of a group section, in which global variables and constants are declared; optional procedure and function definitions, which may contain local variable declarations; and a main procedure.

The UPL repertoire of statements is limited in comparison to general-purpose programming languages, but it includes the essential programming constructs, IF. . .THEN. . .ELSE. . .ENDIF, and LOOP. . .END LOOP, as well as the expected assignment, input, and output statements, and a GOTO statement. This last inclusion reveals the program's FORTRAN heritage.

This language includes statements and functions that are tailored to interact with Personal Designer's GCD screen. Input can be accepted by a UPL program from the keyboard and the pointing device. Windows can be defined and sized dynamically, and alphanumeric output can be written to windows. A full complement of file-handling functions is provided as well.

The primary interface the user has with GCD is the SEND statement, which invokes GCD commands as if they have been typed at the keyboard or picked from a menu. Commands invoked with SEND can be echoed in a window, or executed silently, depending upon the setting of a toggle.

The key feature in a CAD user programming language is its ability to access the drawing database directly. UPL provides four basic, essential statements that add entities to the database, retrieve information about an entity in the database, remove an entity from the database, and modify the graphic attributes of an entity in the database. Of course, the variety of entities to which these statements can be applied requires the use of key words and parameters in order to specify the exact action desired. The number of possible combinations is large and provides total access to the database.

UPL programs must be written outside of GCD and compiled before use. The compiler produces an intermediate code file and an optional list file. Once a program compiles successfully, it is ready for execution under GCD. A UPL program is normally invoked with the **RUN <file name>** statement, typed at the GCD command prompt. In some Personal Designer configurations, a command can be added to the verb/noun table, which allows the UPL program to be invoked directly without the use of the RUN verb.

Two menu systems are furnished with the Personal Designer system: a screen menu and a tablet menu. Both menu systems provide access to essentially all of the basic commands, but not to some of the advanced functions or to seldom-used command sequences. Thus, a designer can use either menu exclusively, or both in concert. Sooner or later, however, keyboard input will be required to proceed.

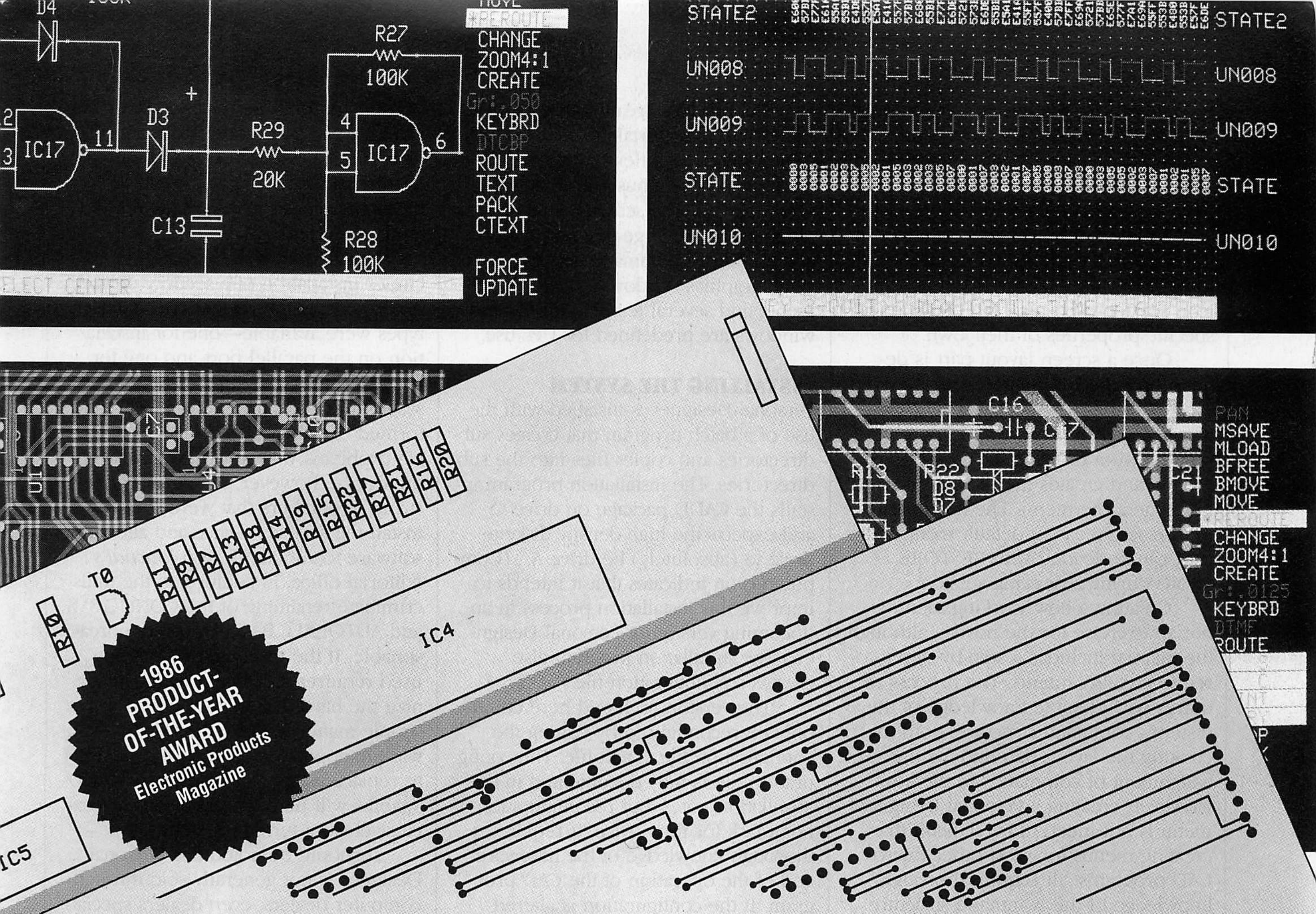
The tablet menu overlay provided with the system is divided into a screen pointing area that is 7 inches wide by 5 inches high, and an L-shaped menu key area. Moving the tablet cursor inside the screen pointing area provides access to the graphics window and the on-screen menu; moving it outside the area provides access to the menu key commands. The description of the overlay and the meanings that are assigned to the keys are recorded in a separate file that can be edited to change the layout and key meanings.

The configuration file stores the name of the default tablet menu file, which is the tablet menu that is active at the beginning of a new drawing session. A different menu file can be activated during a drawing session using the RESTORE TABLET command entered at the command line.

Whereas the tablet menu is a flat menu, the on-screen menu has a hierarchical structure. Selecting a menu key can invoke a command or portion of a command, or activate a submenu. The standard screen menu is structured to display submenus according to the options that are available at each stage of the command entry.

Screen menus are stored as binary files that are created from screen layout parts, drawings of the screen. Creating a menu consists of creating the screen layout part, and then compiling the part to produce the menu file. A screen layout part defines both the appearance of the screen and the functions of the various areas of the screen. The screen layout can contain 20 alphanumeric windows, 1 graphics window, and an arbitrary number of menu windows.

The keys in a menu are closed strings. A key can contain an icon—text,



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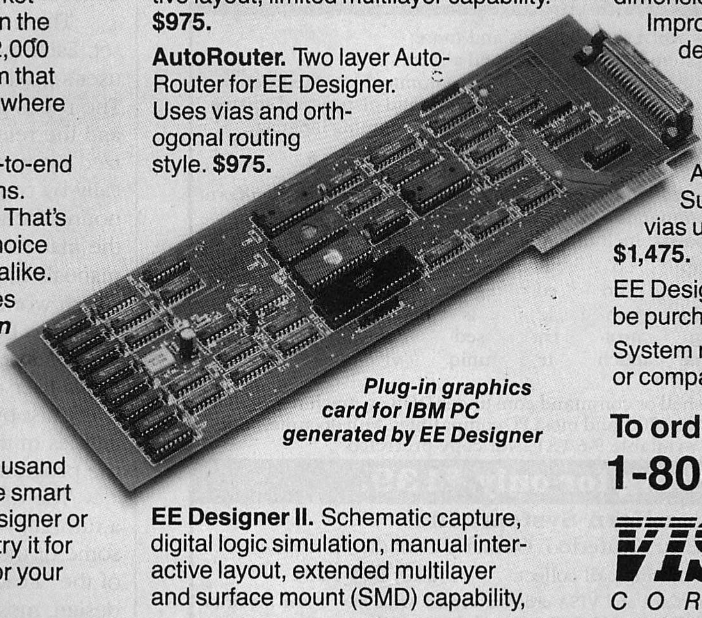

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graphics, or both—and an icon graphic can span several keys. A command is associated with a key by attaching one or more properties to the string that defines the particular key.

The hierarchical menu structure is implemented via layers. A group of menu icons on a layer constitutes an icon set. Icon sets also can be assigned specific properties of their own.

Once a screen layout part is defined or edited, a binary menu file is created using the BUILD MENU command. This command examines a screen layout drawing displayed on the screen, and creates the file necessary to implement the menu. The new menu can be set up as the default menu file, or it can be loaded with RESTORE MENU during a drawing session.

Creating a new working menu is not an exercise for the novice, although the manual includes a step-by-step tutorial in creating menus. The process requires considerable knowledge of the system's command structure, both for creating the layout part and for the assignment of commands to the keys. However, creating a Personal Designer menu is not much more difficult than creating menus for most other micro CAD programs; all require thorough knowledge of the command structure.

The effort of creating Personal Designer menus is certainly justifiable. The system offers total flexibility, not only in the creation of menus, but in general screen layout. The screen layout can range from one large graphics window and a minimal command window, to a small graphics window, a large screen menu, and several text windows. Nine windows are predefined for UPL use.

INSTALLING THE SYSTEM

Personal Designer is installed with the use of a batch program that creates subdirectories and copies files into the subdirectories. The installation program installs the CADD package on drive C:, and expects the high-density diskette drive to (absolutely) be drive A:. (Computervision indicates that it intends to improve this installation process in an upcoming version of Personal Designer.) The installation program also creates a configuration file.

The version reviewed here could only be reconfigured by editing the configuration file, a text file. The configuration file is fully documented in the installation notes, but reconfiguration is not a task for the novice. It requires a thorough knowledge of the hardware and of the operation of the CAD program. If the configuration is altered beyond recognition, however, it always can be restored to the distribution version by rerunning an install program—not the batch file that copies all the files—but a program that only rebuilds the configuration files.

Installation of the program includes installation of a security device. At the time of the review, two different types were available—one for installation on the parallel port and one for installation between the keyboard and system unit. The program must be informed of the type of device installed. No problems were encountered with the device; however, the never-ending string of numbers that were needed to install the security device and allow the software to run at *PC Tech Journal*'s editorial office, in addition to the indiscriminate renaming of the CONFIG.SYS and AUTOEXEC.BAT files, seem unreasonable. If the machine that is being used requires a device driver to recognize the hard disk this is deleted. It is a simple matter to design installation software to append to existing files and not to replace them. Not all users of CADD systems will be buying the software exclusively as a turnkey system.

It should be noted that Personal Designer is not generally sold through computer dealers, even dealers specializing in CAD. It is usually sold through Computervision representatives or sales offices, and often as a turnkey system including a substantial amount of onsite training. Thus, installation will not be of concern to many users.

Personal Designer GCD is contained in four diskettes, Surfaces, UPL, and PDFEM each on a single diskette. An additional utility program disk and a demo disk are included.

The manuals are IBM-size and typeset. Each module typically includes a user's guide and a reference manual. The user's guides are tutorial in nature, and the reference manuals are organized by commands, arranged alphabetically by command verb, then command noun. The indexes included in each of the manuals are inadequate. All of the manuals include examples, most of which worked. The program is designed to be purchased with training. However, a few glitches notwithstanding, a user can learn the system effectively just by working through the examples in the manuals. Once learned, the program is easy to use.

The distribution disks also include a tutorial, written in UPL. Although some of the screens in the tutorial are of the "Read this, press C to continue" design, most require user input to

GCD. The UPL program checks the input, passes the correct input through to GCD, and rejects the incorrect input. Although the tutorial does not include coverage of surface modeling, it covers three-dimensional wire-frame modeling and detailing very well.

DOES IT STACK UP?

How does Personal Designer stack up against AutoCAD, VersaCAD, CADvance, Cadkey, and other microcomputer-based CAD systems? The answer is that Personal Designer is a more capable system than any of those named.

Personal Designer provides an almost ideal mix of modeling and production drafting capabilities. For pure conceptual design modeling, some may prefer a package that offers solids as primitives, rather than Personal Designer's wire-frame facility. But, UPL provides a way to implement three-dimensional, wire-frame objects, with or without surfaces—not solid modeling, but close enough for most purposes.

Computervision is to be commended for supporting such a substantial subset of their full system in the microcomputer environment. If they, or any major CADD vendor, had placed such a powerful program on the market concurrently with the advent of the IBM PC, the CAD market would be much different than it is today.

Personal Designer appears to be as responsive as most moderately loaded minicomputer-based systems, although the two types of systems were not compared directly. With the 6-MHz AT and the Heathkit H-248 systems, Personal Designer is as responsive as any of the microcomputer-based CAD systems listed above, with few exceptions.

However, the manner in which Personal Designer handles parts inserted as figures can lead to a substantial number of disk accesses during drawing regeneration, even of small drawings. In fact, screen repaints generally require disk access, which imposes a speed penalty in comparison to programs that redraw the screen from a display list in memory. Finally, selecting commands from the screen menu also requires disk access, as the screen menu must be redrawn to display submenus. All of that notwithstanding, Personal Designer is reasonably fast.

It should be noted here that speed of redraws, of loading drawings initially, and of executing commands, should not be the principal criteria for selecting a CAD system. More important criteria include the number and types of automated tasks; the degree to which the system's operation resembles the way designers work; and the facilities for customizing the system. In terms of capabilities, this product is outstanding.

Personal Designer is a high-performance, three-dimensional design and detailing system. It provides a substantial subset of a minicomputer CADD system's capabilities, in a microcomputer environment. It also maintains compatibility with the larger system, providing a smooth upgrade path. A Personal Designer system can operate as part of a larger Computervision system, or stand-alone. It may not be the ideal program for all micro CAD users—cost is one factor, the learning curve another. But, if performance and capability are the main criteria, it is a strong contender. Personal Designer is highly recommended.

Computervision Corporation
15 Crosby Drive
Bedford, MA 01730
617/275-1800
GCD, $5,800; Surfaces, $2,800; FEM, $1,500; UPL, $500

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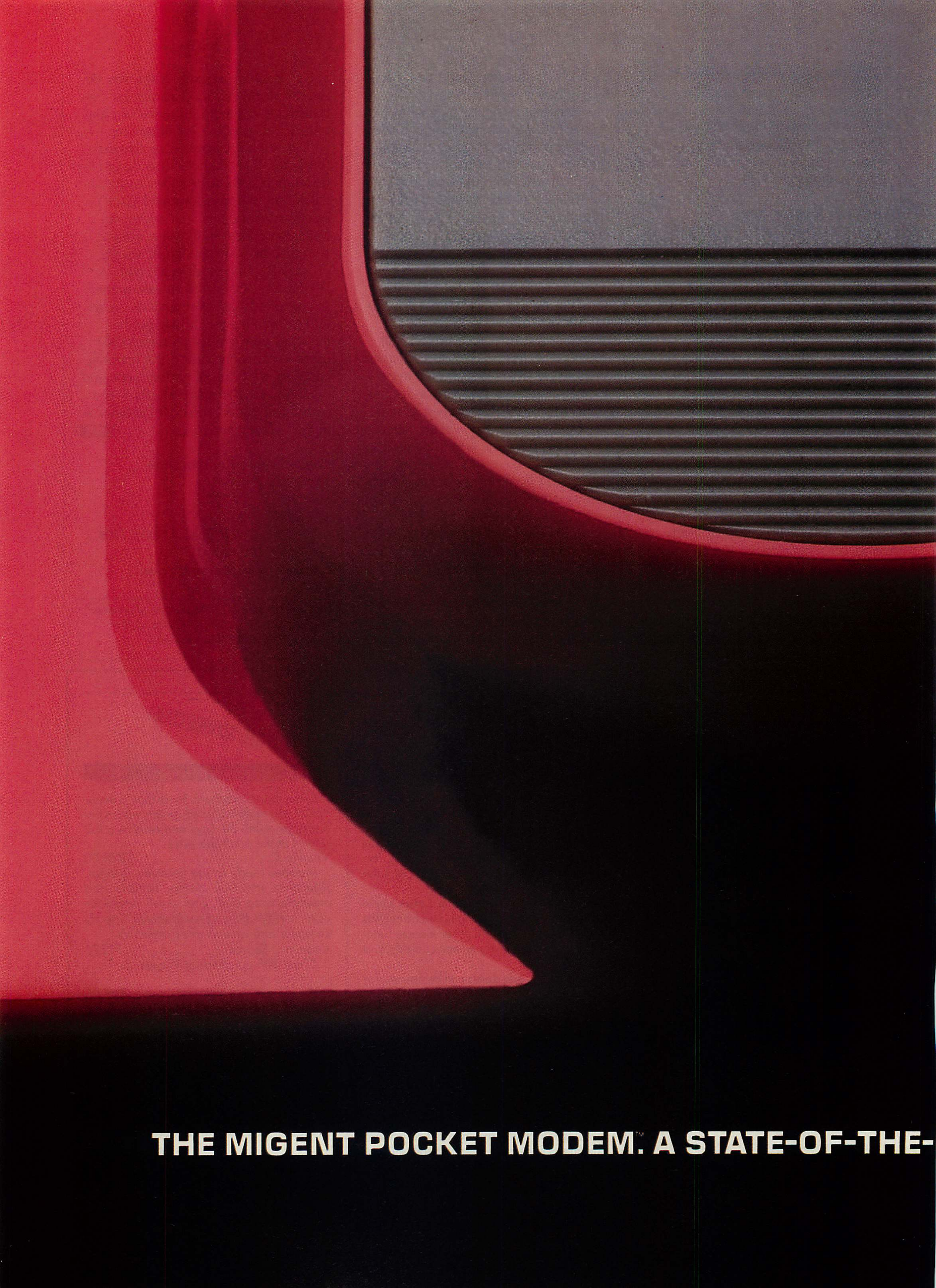
Victor E. Wright is the manager of process engineering at Luckett & Farley, a firm located in Louisville, Kentucky.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CIRCLE NO. 163 ON READER SERVICE CARD

A Resident Exception Manager

An interrupt handler can be installed to allow resident Ctrl-Break or critical error handling routines to take control during the execution of a program.

TED MIRECKI

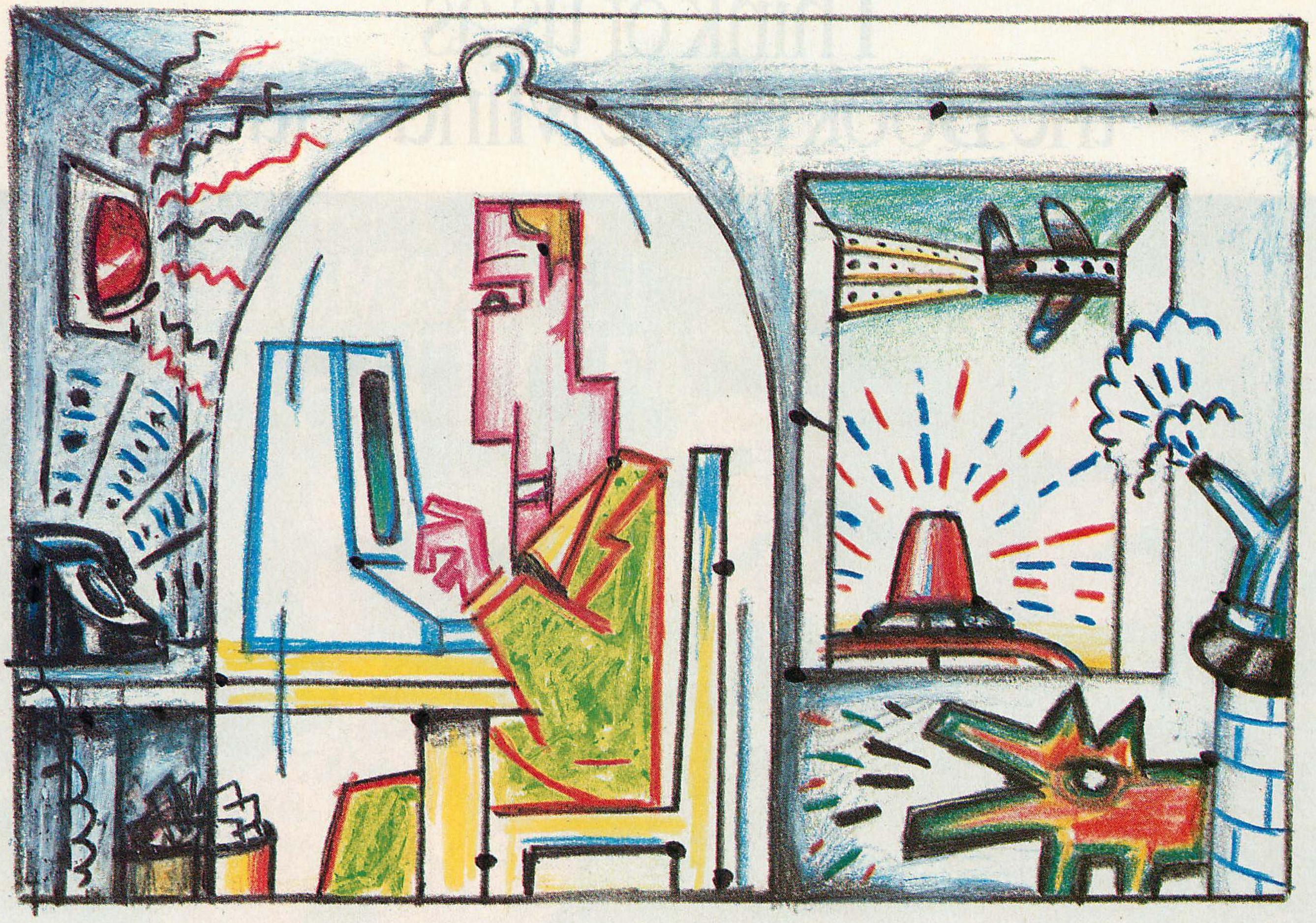
Many services provided by DOS are available through interrupt handlers. In practice, the address of the code providing a particular service, such as sending data to (or receiving it from) peripherals, is available in a location in memory accessible to any program: the interrupt vector table that is in the lowest 1KB of system memory. System programmers who are not satisfied with the way DOS handles those functions can write their own routines and point the appropriate interrupt vectors to them, effectively replacing the standard code with customized interrupt handlers. DOS provides several functions to support the replacement of interrupt handlers: functions 35H and 25H of interrupt 21H read and set a given interrupt address, and function 31H and interrupt 27H can be used to install resident interrupt handling routines.

But three interrupts—22H, 23H and 24H—are not amenable to replacement in this fashion. These perform some very important functions: interrupt 22H points to the return point after a program terminates; interrupt 23H to the code that handles a Ctrl-Break; and interrupt 24H to the critical error handler that is invoked on device errors. (The standard DOS error handler issues the infamous "Abort, Retry, Ignore" message.) Those not satisfied with the way DOS handles these functions might try to replace them with customized interrupt handlers in the usual fashion, but to no avail. The DOS documentation for interrupt 27H states: "This interrupt restores the interrupt 22H, 23H, and 24H vectors to the values they had on entry to the program. Therefore, it cannot be used to install permanently resident Ctrl-Break or critical error handling routines."

This statement sounds like a definite challenge. Notice that the DOS manual does not claim that replacing these interrupt handlers is impossible, just that such replacement cannot be done with interrupt 27H. Although no such caveat appears in the documentation for function 31H of interrupt 21H (which also performs an "exit and remain resident" operation), that function operates in the same manner. How, then, is one to install such interrupt handlers? If they are not to be replaced, why are they provided as interrupts?

To answer the second question first, the interrupt addresses are available to be replaced only during the execution of a program. While a program is running, it may repoint the interrupts to its own routines (see "DOS Exception Handling," Dan Rollins, this issue, p. 130). Upon termination, however, DOS restores the original interrupt addresses. A program, therefore, can be written to provide its own Ctrl-Break and error handling during its own execution, but the program cannot leave these routines behind to service programs executed subsequently.

Because a program cannot leave behind an active break or error handler once it terminates, the trick is not to terminate the program that provides these interrupt services, but to suspend it during the execution of a subsequent program. This is exactly the operation performed by the EXEC function (4BH) of DOS. The way to customize these stubborn interrupts, then, is to install a



handler for interrupt 21H, function 4BH. As it happens, COMMAND.COM also uses the EXEC function when it executes programs with names that are typed at the DOS prompt, so a resident EXEC handler can provide customized interrupt 22H, 23H, and 24H services for any program run under DOS.

Fortunately, it is not necessary to duplicate everything that the EXEC function does in order to load and execute a program. Most details can be left to the original EXEC code in DOS. The interrupt handler need only repoint interrupt 23H to the desired Ctrl-Break handling, arrange for the child process to return to it instead of to DOS for post-termination processing, and then let DOS perform the actual EXEC call.

The program RES22-23.ASM (listing 1) demonstrates the means of installing a resident interrupt handler for interrupts 22H and 23H. (Interrupt 24H error handlers are beyond the scope of this article, but the same principles apply for installing them.) The installation method, not a specific interrupt service, is illustrated, so the following description concentrates initially on the means of transferring control into and out of the routines. The break-handling and post-processing routines in RES22-23 are merely suggestions. Using this method, customized services may be provided for any particular purpose.

RES22-23 is installed in the normal fashion as a resident program to service interrupt 21H. The initialization code at label INIT saves the original interrupt 21H address, resets this interrupt to the address of the new EXEC handler, and fixes the program in memory with interrupt 27H. When an interrupt 21H occurs, the code at label EXEC checks to see if the function code in register AH is 4BH (EXEC). If not, a long jump is taken to the saved original interrupt 21H address, and RES22-23 is no longer involved. DOS handles the function normally, returning to the program that issued the call to DOS.

When the function code is 4BH, however, RES22-23 springs into action. It repoints interrupt 23H to its own Ctrl-Break handler at label INT23 in the program, saves the return point (the address of the instruction following the interrupt 21H that caused the entry into the program), and performs a far CALL to the original interrupt 21H address within DOS. At entry to DOS, the stack is in a proper state for an interrupt: a far address is at the top, followed by the flags. It does not matter to DOS that the address points to a resident routine instead of the location where the original interrupt 21H occurred.

DOS now performs the EXEC function, loads the requested program, and then runs it. If a Ctrl-Break is detected during execution, DOS executes an interrupt 23H, returning control to the resident program, which performs any desired processing and either terminates or returns to continue with the interrupted child program's process.

When the child program terminates, it returns to DOS. After termination processing, DOS returns to RES22-23 at the instruction following the far call. There, the flags and register AX are saved in case DOS is returning an error code (such as file not found or insufficient memory), then the desired post-

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processing (proc POSTPR) is performed. If desired, the post-processing may be skipped in case of error.

The exit sequence from RES22-23 consists of restoring the error status (flags and AX) that was saved on return from DOS, followed by a long jump to the return address that was saved on entry. This returns control to the program that issued the original EXEC call (perhaps COMMAND.COM), which is none the wiser that the call was intercepted by a resident program.

The desired effect—a terminated program returning to a resident post-processor—is achieved without directly changing the address in the interrupt 22H vector. Actually, the vector is changed to point to the resident program, but this is done by DOS as part of the EXEC function processing. At the end of its termination process, DOS places the address from the top of the stack into interrupt 22H and executes that interrupt. This scheme merely arranges for the proper address to be on top of the stack at the proper time.

One major detail needs to be taken care of: a program invoked by an EXEC call may in turn issue another EXEC to run another child process. This means that RES22-23 must be reentrant. To illustrate, suppose COMMAND.COM issues an EXEC for the program ABC. RES22-23 is entered, the return point in COMMAND.COM is saved, and program ABC is started. If ABC in turn issues an EXEC for program XYZ, RES22-23 is again entered and now saves a return point within ABC. When XYZ terminates, RES22-23 regains control and returns to the last saved address, the one in ABC. But when ABC terminates, RES22-23 returns to COMMAND.COM only if the first return address has not been overwritten by the second one.

Normally, reentrance is handled by a stack structure, and the 8086/88 microprocessors implement a stack automatically. In most cases, it would be sufficient to save the return value on the stack because each entry would provide a pointer to a new stack location. But the EXEC function is a special case because it does not guarantee preservation of the stack—that is, the Stack Segment (SS) and Stack Pointer (SP) registers may not have the same values after return from an EXEC as they had before. In personal practice, the stack registers have yet to be disturbed after return from an EXEC, but DOS documentation claims it is possible, so it is best to allow for it. Therefore, RES22-23 implements its own stack structure for saving each return address. This customized stack is implemented in the Program Segment Prefix at CS:0. This area is used only during the installation process, and, thereafter, becomes dead storage available for writing by the program after it becomes resident. For a .COM program, this area is in the same segment as the code, so the role of the SS register is played by the CS register, and the SP register is simulated by a data word that is stored in memory at label RETPTR in the program.

At initialization, the stack pointer is set to point to the end of the PSP, and it is decreased by 4 bytes (because each far return address is a double word) before each push to the stack and incremented by 4 after each pop. That way, RETPTR points to the last return address saved, just as SP points to the last word pushed onto the real stack, and the custom stack grows downward in memory. The 256-byte length of the PSP allows for saving 62 levels of return addresses (6 bytes of the PSP are used to save the original interrupt 21H address and the RETPTR value); in the unlikely event that EXEC calls are nested deeper than this, a system crash will result.

Now that the method of installing resident interrupt handlers 22H and 23H is available, what useful work can such handlers perform? Why would it be necessary to replace the standard Ctrl-Break handling of an existing program? The answer lies in the fact that the manner in which DOS handles the Break key was significantly changed in version 2.0. However, some programs have not been updated since DOS version 1.x; they do not, for example, support path names and mishandle Ctrl-Break, sometimes with disastrous results. Specifically, MicroPro's WordStar and the IBM Professional Editor are two such programs, and both are used often in a programming environment for source code maintenance.

These early programs make no provision for handling Ctrl-Break because they were written under the assumption that DOS can only recognize the Break key during character I/O. Under DOS 1.x, as long as no DOS functions are called to perform character I/O, the Break key cannot be recognized and the break-handler interrupt cannot be invoked.

In DOS 2.0 and later, however, the operating system may be directed (by means of the BREAK ON command) to check for the Break key at every DOS function. This is especially useful to programmers who might want to interrupt a long compilation. When a compiler is running, pressing Ctrl-Break will

have no effect until the compiler next writes to the screen, but if the next message is "Compilation complete," it might be a long wait. Running the compiler with BREAK ON solves this problem because the Break key is recognized at the next DOS call of any type, and a compiler makes frequent calls for disk I/O when reading the source and writing the object file. On the other hand, leaving the BREAK switch on can cause other problems with programs that do not make provisions for such comprehensive break checking.

Once the compilation is interrupted, the programmer will typically call up an editor to work on the source program. For example, suppose that during the edit session, the Ctrl-Break key is pressed by mistake instead of the Ctrl-NumLock or Scroll Lock. The editor is smart enough to ignore this, but the BIOS keyboard routine records the break in the DOS break flag. Now, at the next DOS function, which is typically a save to disk, DOS recognizes the break and invokes the break handler. If the default handler is in effect, it immediately exits the editor, dumping the newly updated file into the bit bucket. This situation would be avoided if the editor could be provided with a customized break handler.

Within an editor, the preferred response to the Break key is simply to ignore it. But once outside the editor and back inside the compiler, the default action of exiting to the operating system is desired. It is possible, however, to write one resident handler that can accommodate both needs.

In the program given here, the interrupt 23H (Ctrl-Break) handler does two things. First, it issues a more informative message than ^C (in the example, it is *BREAK*, but it may be anything the programmer desires). Despite what DOS documentation implies, the ^C is output before, not after, the call to interrupt 23H, so the output of the resident break handler will be in addition to, not instead of, the standard ^C. Second, it terminates the program with an error level of 8. This is especially useful for programs invoked from a batch file.

When a batch file is interrupted with Break, the default break handler queries the user whether to terminate the batch stream or to continue with the next command. The customized handler illustrated below returns to the batch file, allowing a subsequent IF ERRORLEVEL statement to make the decision without user intervention. The batch file could be written to perform a cleanup sequence if a program is interrupted with Ctrl-Break. The problem with the Break mishandling in the editor could be handled by the following batch file for compilation:

```
BREAK ON
COMPILE %1
IF ERRORLEVEL 8 GOTO :CLEANUP
LINK %1
:CLEANUP
BREAK OFF
```

The BREAK switch is turned off after the compilation, even if the compiler is interrupted with the Break key. Therefore, a subsequent editing session cannot be aborted by the mishandling of the Break interrupt.

The post-processing performed by the example program is for data security—it clears all memory after each program terminates. This prevents snooping with DEBUG to discover possibly sensitive data left in memory by a word processor or database manager. The clearing of memory occurs unconditionally after every program without any effort by the user, so it is safer than writing a batch file to run a memory clearing utility after each application, and infinitely more convenient than requiring a system reset after terminating a session with sensitive data.

The clearing process works by tracing the DOS memory allocation blocks and writing zeroes to all blocks that do not belong to an active process. The format of memory allocation blocks, and how to determine if they are unowned, was previously described in some detail in "Managing Memory," (William Redmond, August 1984, p. 43). There are two minor inconveniences: a slight delay between program termination and the next system response, and the fact that COMMAND.COM must be reloaded after each program. The latter occurs because the transient portion of COMMAND.COM resides in memory that is not allocated, so this memory is wiped out. No easy method exists to determine where COMMAND.COM begins in high memory.

Critical error handlers are not limited, therefore, to functions determined solely by DOS. Interrupt-handling routines can be used to improve the Break key and error-handling ability of any program. Also, data security can be increased by using of post-processing techniques, even when a program is terminated unexpectedly.

Ted Mirecki has been a contributing editor to this magazine for three years. He recently joined the editorial staff at its location in Columbia, Maryland, as a technical editor.

LISTING 1: RES22-23.ASM

```
COMMENT "       PROGRAM RES22-23  by Ted Mirecki.

Demonstrates installable resident interrupt handlers for Terminate
Address (INT 22H) and Ctrl-Break (INT 23H).  After installation,
these routines will be used by all programs in lieu of standard
DOS handlers for these services.

The INT 22H handler clears memory after each program to prevent
snooping with DEBUG.

The INT 23H handler displays *BREAK* along with standard ^C, and
ends any program with errorlevel 8 for subsequent testing in a
batch file.

This program is meant to be converted to a COM file.  "


CODE    SEGMENT 'CODE'
        ASSUME  CS:CODE, DS:NOTHING, ES:NOTHING, SS:NOTHING

        ORG     0FAH                    ;Use PSP for data area
RETPTR  DW      ?                       ;Ptr to last save address
INT21   LABEL   DWORD                   ;Original INT 21H vector
OFF21   DW      ?
SEG21   DW      ?

        ORG     100H
ENTRY:  JMP     INIT


; EXEC Proc replaces DOS EXEC function.  Any program executed
; from DOS (by COMMAND.COM or by another process) returns here
; for post-termination processing.


EXEC    PROC
        CMP     AH,4BH                  ;Is it EXEC call?
        JE      X1                      ;Yes: handle it here
        JMP     CS:INT21                ;No:  let DOS handle it

X1:     PUSH    AX                      ;Save registers
        PUSH    DX
        PUSH    DS
        MOV     AX,CS
        MOV     DS,AX                   ;Point DS:DX to CS:INT23
        LEA     DX,INT23
        MOV     AX,2523H                ;Point INT23 vector there
        INT     21H
        POP     DS
        POP     DX
        POP     AX

        SUB     CS:RETPTR,4             ;Update save area pointer
        MOV     SI,CS:RETPTR            ;SI -> Current save address
        POP     CS:[SI]                 ;Save return address
        POP     CS:[SI+2]
        CALL    CS:INT21                ;Perform EXEC function


; Any program executed from DOS (by COMMAND.COM or by another
; process) returns here for post-termination processing.


        PUSHF                           ;Save error status
        PUSH    AX
        CALL    POSTPR                  ;Perform post-process
                                        ;Exit sequence
        MOV     SI,CS:RETPTR            ;Get return address
        ADD     CS:RETPTR,4             ;"Pop" the custom "stack"
        POP     AX                      ;Restore & return
        POPF
        JMP     DWORD PTR CS:[SI]
EXEC    ENDP

POSTPR  PROC    NEAR                    ;Clear memory
        MOV     AX,CS                   ;Get current segment
        DEC     AX
        MOV     DS,AX                   ;Point DS to memory control block
```

```
X2:     ADD     AX,DS:[3]           ;Point to end of block
        INC     AX                  ;Point to next ctrl block
        MOV     DS,AX
        CMP     WORD PTR DS:[1],0       ;Is block in use?
        JNZ     X5                  ;Yes: skip the fill
        INC     AX                  ;No:  point to its start
        MOV     ES,AX
        MOV     DX,DS:[3]           ;Get length of block
        MOV     CL,4
        ROL     DX,CL               ;Convert to bytes
        MOV     BL,DL               ;Get full segments in BL
        AND     BL,0FH              ;Any full segments?
        JZ      X4                  ;No:  go do partial segment

X3:     XOR     AX,AX               ;Yes: fill it with zeroes
        MOV     DI,AX               ;Start at offset zero
        MOV     CX,8000H            ;Words in full segment
        REP     STOSW               ;Fill the segment
        MOV     AX,ES               ;Point to next segment
        ADD     AX,1000H
        MOV     ES,AX
        DEC     BL                  ;Any more full segments?
        JNZ     X3                  ;Yes: repeat

X4:     AND     DX,0FFF0H           ;Any partial segment?
        JZ      X5                  ;No:  done with this block
        SHR     DX,1                ;Yes: convert to word count
        MOV     CX,DX
        XOR     AX,AX               ;Clear partial segment
        MOV     DI,AX
        REP     STOSW
        MOV     AX,DS               ;Restore AX to block addr
X5:     CMP     BYTE PTR DS:[0],'Z'     ;Is this last block?
        JNE     X2                  ;No:  loop for next block
        RET
POSTPR  ENDP


; Data for INT23 Proc.


CTRLBRK$        DB      0DH, 0AH, '*BREAK*', 0DH, 0AH
MSGLEN  EQU     $-CTRLBRK$


; INT23 Proc is executed whenever Ctrl-Break is recognized.


INT23   PROC
        LEA     BX,CTRLBRK$         ;Point to message
        MOV     CX,MSGLEN           ;Get message length

Y1:     MOV     DL,CS:[BX]          ;Get next character
        MOV     AH,6                ;Console output function
        INT     21H                 ;Send to standard output
        INC     BX
        LOOP    Y1

        MOV     AX,4C08H            ;Set return code 8 & terminate
        INT     21H
INT23   ENDP

INIT    PROC
        ASSUME  DS:CODE
        MOV     AX,3521H            ;Get current INT 21H address
        INT     21H
        MOV     OFF21,BX            ;Save it in data area
        MOV     SEG21,ES
        LEA     DX,EXEC             ;Replace with new address
        MOV     AX,2521H
        INT     21H
        LEA     AX,RETPTR           ;Initialize addr pointer
        MOV     RETPTR,AX
        LEA     DX,INIT             ;End of resident code
        INT     27H                 ;Terminate & stay resident
INIT    ENDP
CODE    ENDS
        END     ENTRY
```

AW . . .

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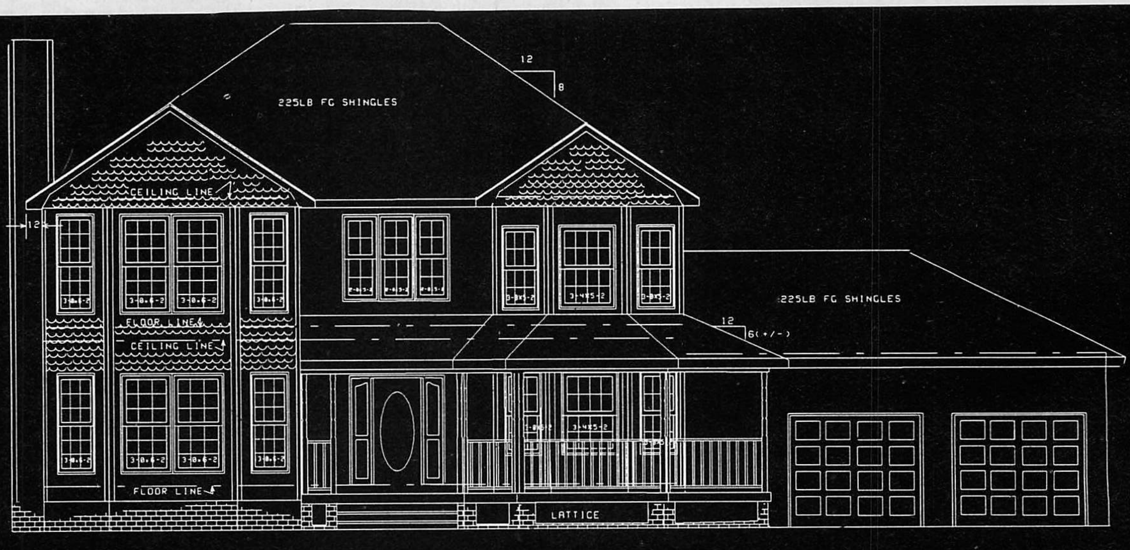

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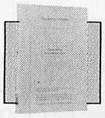
1/4" = 1' 0"

Reviews and Updates



TOM RETTIG'S LIBRARY, CLIPPER EDITION
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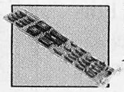
R-CARD
Rodime, Inc.

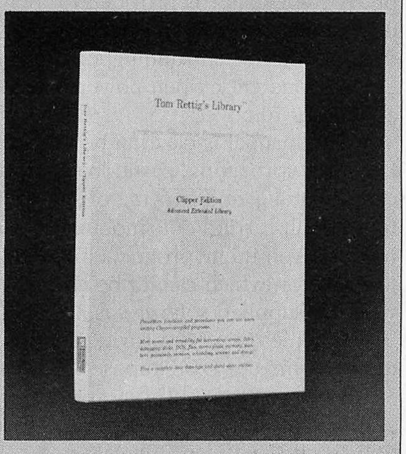


MEGA
Mylex Corporation

TOM RETTIG'S LIBRARY, CLIPPER EDITION

Tom Rettig Associates
9300 Wilshire Blvd., Suite 470
Beverly Hills, CA 90212
213/272-3784

PRICE: $99.95



CIRCLE 349 ON READER SERVICE CARD

Tools of variety and quality distinguish a professional toolkit; for programmers working in a compiled language, one useful tool is a library of routines that link with programs for integration into applications. Tom Rettig's Library, Clipper Edition, Advanced Extended Library, by Tom Rettig Associates, is a professional, easy-to-use tool for the programmer working in the dBASE language using the Clipper compiler by Nantucket, Inc. (see "Dialects of dBASE," Ted Mireki, this issue, p. 46).

The Clipper compiler allows programmers to write user-defined functions (UDFs), link them with a compiled dBASE program, and execute them from within the program. The Clipper Edition of Tom Rettig's Library provides more than 150 prewritten functions and procedures for use in developing Clipper-compiled programs. Only representative examples in each category follow.

Arrays. Clipper's array-handling capabilities are enhanced with 15 functions and procedures, such as READARRC, which reads a character array from disk.

Business. Eight functions provide various business aids, such as DEPDB(), which calculates depreciation by declining balance, and TOMONEY(), which expresses numbers in dollars and cents for applications such as check writing.

Character. Nineteen functions process text and characters, such as CENTER(), which automatically creates a string of a given length with the specified text centered within the string.

Database. Eight functions help manage database files, such as FLDCOUNT(), which returns the number of fields in the file structure.

Date. Eighteen functions process dates, such as BOW(), which returns the date of the previous Monday (that is, the beginning of the week).

Debugging. Two procedures help to debug programs; one is MEMDUMP, which produces a hexadecimal dump of variable storage.

Disk. Five functions provide disk management. One is CURDRIVE(), which returns the current default drive to help the program manage the disk interface.

Memo. Three functions are useful in the processing of memo fields, such as LINES(), which calculates the number of lines required to output the memo field at a specified line width.

Miscellaneous. Three other uncategorized functions are included, such as STATUS(), which returns the current value of a specified SET switch.

Numeric. Twenty-one functions provide number-processing conversion, such as LOGNBASX(), which checks general logarithmic calculations.

Printer. Five print functions are provided, such as ISPRINTER(), which checks status and manipulates printers.

Screen. Six functions provide screen management, such as CURSOR, which turns the cursor display on and off.

System. Twenty-one advanced functions and procedures direct interface with the computer system, such as REG(), which reads the contents of a CPU register.

Time. Twelve functions manipulate time, such as TIMESTR(), which creates a time string from a number of seconds.

Stand-alone utilities. Five stand-alone programs are provided, such as FATTRIB, which modifies file attributes.

No advanced programming skills beyond those needed to create programs with Clipper are needed to use the functions and procedures in Tom Rettig's Library. The programmer simply refers to the desired function or procedure as if it were an existing dBASE III or Clipper function or procedure, compiles the program, and names the library (along with the standard Clipper library) at the link step. If the compiler cannot recognize the name of the function (for example, if the function is generated through macro substitution), it must be named in an EXTERNAL statement in the calling program. Procedures are executed with either the CALL or the DO statement. Minimal error trapping in the library's routines provide maximum performance—the documentation wisely cautions careful and proper use of the routines.

The routines are written in dBASE, assembly language, and C, as appropriate. In addition to the object files used for linking, all source code is included. Thus, experienced programmers can tailor routines to specific needs; the beginner can learn more about interfacing with C and assembly language using Clipper-compiled programs. Besides the functions called from dBASE programs, the library has a number of low-level, internal routines called by these functions. For advanced programming applications, these routines may be called from the programmer's C or assembly UDFs, but the documentation for these functions is mainly commented source code.

Tom Rettig's Library, Clipper Edition, is provided on three diskettes. Two versions of the library are available: 1.02 is for use with the winter 1985 version of Clipper, and 1.03, for the autumn 1986 version. The documentation consists of 170 loose-leaf pages that are hole-punched for insertion into the Clipper documentation binder. Function and procedure documentation is in a page-per-command format. A plastic reference card also is included. The contents of the user manual are generally clear and complete. An understandable explanation of the license agreement describes how the license grants the right for the programmer to incorporate code from the library into a software application, place the programmer's copyright notices into the application, and distribute copies of the incorporated library code as a part of the application without additional fee. A 30-day satisfaction guarantee and a one-year warranty against significant bugs also are provided; the programs are not copy protected.

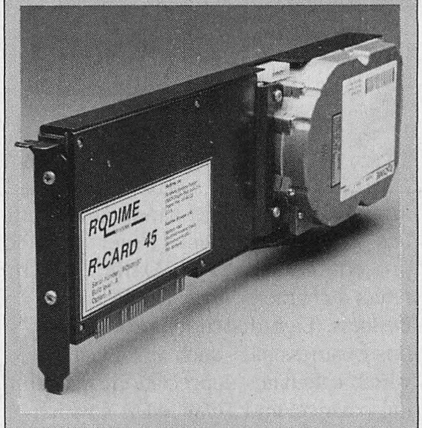
Tom Rettig's Library, Clipper Edition, is a valuable set of tools that should be a part of every programmer's Clipper toolkit.

—DAVE BROWNING

R-CARD

Rodime, Inc.
29525 Chagrin Blvd., Suite 214
Pepper Pike, OH 44122
216/765-8414

PRICE: 37MB, $1,295; 45MB, $1,495



CIRCLE 348 ON READER SERVICE CARD

Rodime R-Cards bring both high performance and high capacity to the world of hard-disk cards. They are available with either a 37MB or 45MB capacity. The test unit was the 45MB model; the 37MB model has the same specifications, but it has one less disk surface.

Each R-Card consists of a Rodime hard disk and a Western Digital controller mounted on a black-anodized metal bracket. The construction quality is excellent; the fit and finish of all parts indicate a high degree of care in design and assembly. The read/write heads are voice-coil activated and, as befits a high-performance disk, they automatically park and lock when power is removed, minimizing the chance of a head crash.

The R-Card can be installed as the first or second hard disk in a system. It consumes 17.1 watts of power while running and even more at start-up, so a 135-watt power supply is needed. The R-Card uses one full slot if installed in the far left slot (with the speaker moved); otherwise, the slot next to it is limited to short cards only. While the controller receives all its power from the computer's bus, the disk requires a separate connection to the power supply. A Y-connector is provided for power supplies that lack an extra lead. Although quiet when running, the unit emits a loud click when power is either applied or removed.

The manual is clear and complete. Low-level formatting, partitioning, logical formatting, and copying of system files are all carried out smoothly by a menu-driven utility program. The interleave factor, which cannot be changed with the supplied software, is 3.

Rodime does not provide a utility to overcome the DOS-imposed limit of 32MB per volume, but some readily available products do perform this function (such as Golden Bow Systems' VFeature Deluxe). The R-Card can be divided into as many as eight logical disks with a total capacity of 45MB. No problems occurred when using various hard-disk utilities (such as Fifth Generation Systems' Fastback, Executive Systems' Xtree, and The Norton Utilities) on these configured disks.

To take advantage of this partitioning scheme, logical formatting must be performed using Rodime's software, not the DOS FORMAT program. However, Rodime's formatter establishes wastefully large cluster sizes (as in DOS 2.x). In the unit tested, for example, a 13MB partition was formatted with clusters of 4KB, and a 32MB partition with clusters of 8KB. Disks of this size, formatted using FORMAT from DOS 3.0 (or later), would have clusters of 2KB, allowing more economical use of disk space.

The R-Card is faster than any of the hard-disk cards reviewed in "Mass-Storage Mergers," (Peter G. Aitken, January 1987, p. 76). In fact, with an average ac-

TABLE 1: *Vital Statistics*

SPECIFICATIONS[a]	
Data encoding method	MFM
Interleave factor	3
Power consumption (watts)	17
Warranty (months)	12
Calculated MTBF (K hours)	18
DISK PARAMETERS[a,b]	
Surfaces	6
Tracks	865
Sectors per track	17
Bytes per sector	512
Sectors per cluster	8 or 16
Total space (bytes)	45,173,760
FEATURES[a]	
Activity Indicator	no
All power from bus	no
Runs in 63.5-watt PC	no
Automatic head locking	yes
Factory low-level format	no
Coexistence with 2nd drive	yes
Install program	yes
PERFORMANCE[a] **(ATDISK)**	
Track-to-track seek time (ms)	5.8
Average seek time (ms)	28.8
Effective transfer rate (KB/sec)	84.8
DOS file I/O (seconds)	10.8

[a] *The Rodime R-Card can be compared with other hard-disk cards reviewed in "Mass-Storage Mergers," Peter G. Aitken, January 1987, p. 76. For specifications and disk parameters, refer to table 2 (p. 82). For features, refer to table 1 (p. 80). For performance, refer to table 3 (p. 84).*

[b] *The 45MB R-Card's logical specifications were determined by the utility program INFO.EXE ("Finding Disk Parameters," Glenn F. Roberts, May 1986, p. 112). The R-Card was configured into a 32MB and 13MB drive, INFO run on both, and the results combined.*

The R-Card's performance is excellent. Its average access time is comparable to that of many disks intended for use with the PC/AT.

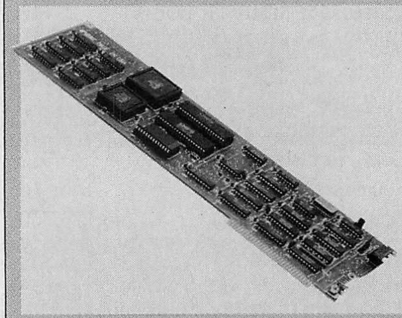
cess time of less than 30 milliseconds, its performance is in the same league with many disks used with the PC/AT. Like all other hard-disk cards, however, the R-Card will not work in the AT because of BIOS incompatibilities. The results of the ATDISK hard-disk benchmark program are shown in table 1.

Both R-Card models provide a level of disk performance unmatched by other hard-disk cards—indeed, their speed is matched by few PC disks of any kind. Such performance can make a big difference, particularly in disk-intensive applications such as large databases. In conjunction with an add-on accelerator board, an R-Card could considerably narrow the performance gap between the PC and the AT.

—PETER G. AITKEN

MEGA
Mylex Corporation
5217 N.W. 79th Avenue
Miami, FL 33166
305/592-9669

PRICE: $399



CIRCLE 347 ON READER SERVICE CARD

Since the IBM Enhanced Graphics Adapter (EGA) has now become entirely a commodity item, users may have a difficult time choosing from among the increasing number of EGA boards on the market. Thus, it is noteworthy when a new entry provides some added feature that differentiates it from other EGAs available.

This is the case with MEGA, a new EGA board from Mylex Corporation. MEGA is a full-length display board that uses Chips and Technologies (C&T) circuitry and the trapping-software technique for Hercules, IBM Color Graphics Adapter (CGA), and Monochrome Display and Printer Adapter emulation. Mylex configured the board with 256KB of video RAM; no parallel or serial port options are available with it.

What sets MEGA apart from other EGA boards is its font-editor utility. With this font editor, the user can design custom fonts, such as mathematical symbols, for use in specific applications. The MEGA font editor can create a font image in C source files, assembly source files, or in straight binary image, and also can load a font into the EGA's font plane. This utility could prove invaluable for redefining fonts and using alternative fonts in text modes.

Otherwise, MEGA's features are not remarkable. Its operation is controlled by eight mode switches that are accessible through the mounting bracket without opening up the system unit. These switches control the initial mode of the display adapter at boot-up, multiple-display-adapter emulation, and the monitor selection. A jumper changes the MEGA's I/O address base from 3xx to 2xx, following the IBM EGA standard.

MEGA supports only the standard EGA operating modes; it does not provide the higher vertical-resolution modes available with variable-scan-rate monitors. However, it does provide the trapping-software solution for CGA and Hercules emulation. The user installs the RAM-resident software that is provided for setting the emulation traps, and it places the board into an emulation mode. Then MEGA will issue a nonmaskable interrupt to the CPU when the software issues I/O instructions to CGA- or Hercules-specific I/O registers. (For further details of the trapping-software method of Hercules and CGA emulation, see "Evaluating the EGA: The EGA Spectrum, Part 2," John Cockerham, November 1986, p. 147.)

The MEGA board was tested using the *PC Tech Journal* EGA test suite described in the aforementioned article. Its C&T hardware passed all tests with ease because it is a replica of the IBM chip set. Like all other C&T boards (and the IBM EGA), MEGA duplicates the first scan line in EGA mode 16 (high-resolution graphics) when the split-screen mode is first entered.

The board could not pass all of the emulation tests; specifically, it could not emulate the CGA low-resolution games, in 160-by-100 mode because the hardware does not support this mode. However, MEGA did pass the FantasyLand test and EGATEST. Both Microsoft Windows and Graphics Software Systems' CGI operated flawlessly in native EGA, CGA, and Hercules modes.

The timing tests confirm the electronic similarity of MEGA to other C&T EGA implementations. The dot-plot benchmark times (65,000 iterations in graphics mode 16) were identical to the times for all other boards for subroutine calls (20.7 seconds) and in-line I/O (17.9 seconds). The BIOS dot-plot time, though, was one of the slowest—49.8 seconds. Examination of the BIOS reveals that function calls are dispatched through a test-and-branch sequence rather than through a transfer table.

Other BIOS errors are present as well. As with the IBM EGA, warm reboots of the CPU take a long time because the software writes over the reboot flag during EGA video RAM testing. Mode changes produce a fair amount of snow on the screen—presumably because video-driver output to the CRT is not disabled during a mode change. The cursor emulation routines are correct; however, the standard double-line cursor is reduced to a single line after additional fonts have been loaded into the font plane. Lastly, the graphics-mode character-painting routines do not paint the characters in user-designated colors.

The BIOS correctly implements the EGA BIOS save-area features, where a copy of the palette is stored, and the Alternate Print Screen routine runs correctly. The Mylex BIOS passes all unrecognized function calls to interrupt 42.

The installation and set-up of the adapter is adequately documented. However, a technical description of the EGA's function is not included.

Like most of the other EGA-compatible display boards, the Mylex MEGA has its share of correctable BIOS bugs. The C&T chip set guarantees compatibility with existing EGA software. Its distinguishing characteristic from the other boards, however, is its font editor; it is an excellent utility. Other font-editing utilities are available, but the bundling of this one with the MEGA may very well be the reason to choose this display board over another one.

—JOHN T. COCKERHAM

Liability and Expert Systems

What are the legal ramifications of developing and marketing expert systems that may surpass their human counterparts in speed and accuracy?

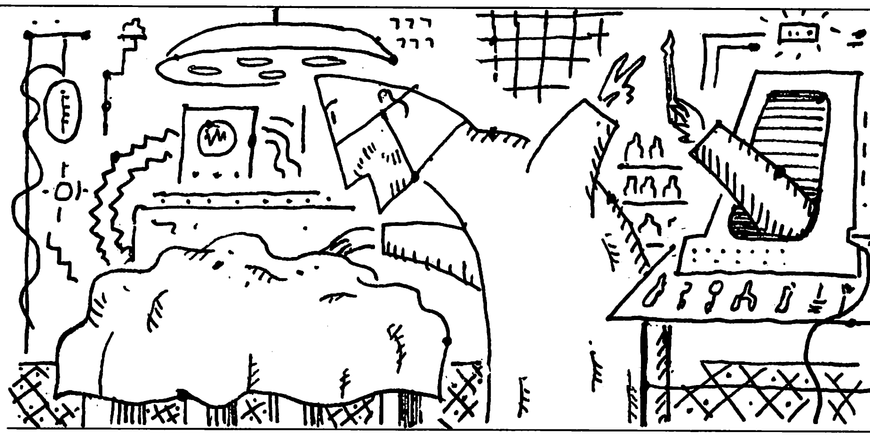


ILLUSTRATION • MACIEK ALBRECHT

The time may be coming when expert systems will take over and then surpass some functions of their human counterparts in professions such as medicine, engineering, law, accounting, and computer science. Presumably, at least in its early stages, an expert system will suffer from many of the same frailties as its human counterpart: it will make mistakes. It has been years since an American court executed a horse as a witch, and it is doubtful that modern precedent exists for "punishing" an offending computer system. However, if a computerized expert system errs and an injury ensues, the fact that the injury was caused by a cold, dispassionate machine rather than a warm human will not likely deter the injured party from seeking compensation.

What are the risks in developing, marketing, and using expert systems? What standards of care are required? Will the day come when it will be malpractice for a professional *not* to use an expert system? (If that comes about, what a terrific marketing tool!)

These questions do not have definitive answers yet: the law is designed to respond to concrete issues rather than hypothetical situations. This article explores some considerations that should be given attention in developing and marketing expert systems. A subsequent article will consider some possible paths the law might take in responding to the emergence of expert systems for professional applications, with a view to developing a strategy for protecting oneself from liability.

For a system in a highly regulated field that poses most of the issues, consider a medical diagnostic system. Other professions are subject to similar types of regulation and accountability.

The developer of a diagnostic system must be aware that medicine is regulated in several areas: the federal Food and Drug Administration (FDA) reviews new drugs and medical devices before they can be introduced into the market; third-party insurers (such as Blue Cross) and federal and state departments of health and human services control the flow of significant funds to health care providers; states license individual physicians to practice medicine. The *malpractice* of medicine is dealt with civilly through lawsuits seeking compensation and in a regulatory framework by suspending or revoking licenses to practice. What are some of the regulatory hurdles that can be expected from these agencies?

One of the first questions to ask is: does the system require FDA approval? The FDA regulates not only drugs but also medical devices, which include "an instrument, apparatus, implement, machine, contrivance...or other similar or related article, any component, part, or accessory, which is ... intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease, in man or other animals. . ." (21 United States Code Section 321).

If the system is within this definition, the developer must submit a premarket notification to the FDA at least 90 days before introducing the device into interstate commerce and again whenever significant modifications are made. All devices subject to FDA jurisdiction must meet general requirements including registration, quality control, and record keeping.

How would the developer go about demonstrating compliance with a performance standard? In the early stages of artificial intelligence, it might be possible to have a panel of experts give second opinions on a system's diagnoses. However, if expert systems advance beyond what humans can do, how would compliance be demonstrated once the system's "artificial" intelligence surpasses the natural intelligence of the evaluators? With luck, while the system is being developed the FDA will have been developing a system expert in evaluating expert systems.

Current payment mechanisms for medical services should be able to add expert systems as an insurable expense. Third-party payment plans typically pay not only the fees of treating physicians, but also the costs of laboratory and diagnostic tests. It should be a short step to the proposition that expert systems are like laboratory tests and therefore should be reimbursed similarly. However, most laboratory tests are not interactive with the treating physician: what if the expert system is used by a physician? (As will be shown, it is potentially beneficial to limit the use of expert systems to experts.)

Certain groups hold the view that many laboratory tests are unnecessary and are performed to protect the physician against malpractice claims rather than to protect the patient (the practice of defensive medicine). Will expert systems be perceived to be in the same category? Will health-care insurers be pressured to limit the use of expert systems as nonproductive?

Although a third-party payment plan cannot dictate how a physician practices medicine, more than half of all payments for medical care are made by third-party plans. The economic impact of the plans' decision on reimbursement will be significant. Can pressure be applied by liability insurers in favor of such expert systems for their potential to reduce malpractice claims?

Another question to consider is whether the system would be "practicing medicine" under state law. While the definition varies from state to state, a good working definition of "practicing medicine" is engaging, with or without compensation, in medical diagnosis, healing, treatment, or surgery. In general, an individual may not practice medicine without a license from the state, but an unlicensed individual may perform duties delegated by a licensed physician. As long as the system is being used solely by licensed physicians, the problem seems to be solved. The system could be designed to function as a laboratory test, and eliminate the physician's involvement.

When the number of people that can use the system is expanded, an organization may run into the thornier issue of how to get a computer program "licensed" to practice medicine. It obviously has not been done yet, and it is not likely to happen before computers get the right to vote, because typical licensing requirements include attaining a minimum age and holding a degree of doctor of medicine from an accredited medical school.

How far can a system go without requiring the unobtainable license? Clearly, it is not practicing medicine to write a textbook on diagnosis: the book can be sold to anyone, licensed or not. The line would be crossed, however, if the purchaser of the textbook began prescribing treatment for others. Still, it would be the reader and not the author of the textbook who would be engaged in the unlicensed activity. Is a computer program an interactive book or an inanimate reader? Should it be considered a source of information or a prescriber of treatment? These are good questions with, as yet, no definitive answers. The answers are extremely important, for they may determine whether developers of these systems (and lay users) would face criminal and civil liability.

Civil liability could arise in a number of contexts. Suppose, for example, that the expert system contains incorrect data. Under the usual nonprofessional contract theory, the parties can generally allocate risks as they choose: if a purchaser agrees to buy a system as is or without warranties, he is stuck with the system, bugs and all, so long as no fraud has been committed. Professionals, however, contractually cannot eliminate or reallocate their liability for prospective malpractice. A doctor cannot sell the patient an appendectomy, as is. As a general rule, a physician must show the degree of skill, care, and judgment ordinarily exhibited by practitioners in the same specialty under similar circumstances in the same locality. It may not be malpractice for a general practitioner in a rural area to be unaware of a recent development in treating an uncommon ailment; however, the same shortcoming might be considered malpractice for a specialist in a large urban teaching hospital.

Where will expert systems fit into this pattern? Will it be permissible to license systems as is? If not, will the systems be held to the same standards as human experts in the same fields? Should it make a difference if the error is not in factual content but rather in design logic? Will expert systems commit "malpractice" if their database is not kept up to date?

The user of an expert system could face similar exposures to liability. Who is responsible if an expert system is used and the system leads to a misdiagnosis? Again, two sets of analogous situations offer relatively clear answers. If a physician refers a case to a specialist and the specialist commits malpractice, that malpractice does not ordinarily make the referring physician liable. On the other hand, if a surgeon uses a scalpel where a catheter was called for, he can be held liable for his inappropriate choice of instruments.

Which is the expert system—a colleague or a tool? Superficially, it would appear that it is a tool. However, that answer may assume too much about how expert systems will develop. The proper distinction may not be between colleague and tool, but rather between tools that the community standard of care requires the physician to understand and discriminate between, and the tools it accepts as beyond the scope of proper medical practice.

People expect surgeons to distinguish between scalpels and catheters, but as technology becomes more complex, will they likewise require that the doctors understand the internal workings of microchips? To respond with the legal standard (that physicians must understand microchips if practitioners in the same specialty and locality under similar circumstances do) is not particularly helpful. If expert systems do progress to the point where they surpass the ability of even specialists in their field, then they will be operating in areas where even the specialist cannot determine whether the system is functioning properly or not. The decision whether or not to hold a physician responsible for errors in an expert system may determine whether or not expert systems come into use. If a physician can limit his malpractice exposure to his own mistakes by eschewing expert systems, but takes on additional exposure by employing them, what will motivate him to use the system (even if, statistically, his diagnoses are better using the system)?

One answer may be the threat of malpractice for *not* using an expert system. An expert, particularly a specialist in a field, is expected to use available, proven tools. The word *proven* brings us full circle to the issues of FDA approval. What standards are appropriate to prove expert systems? The question may be easy to answer as long as expert systems remain in the realm of automating and speeding the solution to problems that humans can solve through other, albeit tedious, methods. However, if the systems learn better than they are taught, the question becomes much more difficult.

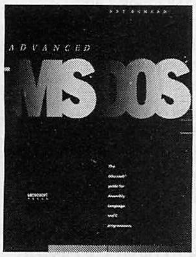
The issue of proving a system is one of extreme economic importance. If a system, either through FDA or some other stamp of approval, is the first to be accepted as the norm for a particular purpose, it will offer a double benefit: protection (perhaps not complete) from malpractice claims and the threat of malpractice for failure to use, a combination that should guarantee substantial market penetration.

Max Stul Oppenheimer, PC, is a partner in the law firm of Venable, Baetjer & Howard with offices in Maryland, Virginia, and the District of Columbia.

Clarifying MS-DOS

An "authorized biography" of MS-DOS enhances the Microsoft documentation and expands the programming possibilities for programmers.

Advanced MS-DOS
Ray Duncan (Redmond, WA: Microsoft Press, 1986) 468 pages; paper, $22.95; disk, $15.95



When a book and its subject share the same corporate parent, the situation is not unlike that of the "authorized biography." On the plus side, the author can count on the company's cooperation in supplying information and ensuring its accuracy. On the minus side, the information may be limited to the official line and provide little beyond the company's documentation that is already in the public record. Happily, in *Advanced MS-DOS*, the positive outweighs the negative.

According to the author's introduction, the book is written for the experienced assembly language or C programmer who is familiar with the architecture of Intel's 8088/8086/80286 microprocessors. It is meant to provide the information necessary to create robust, high-performance application programs using the services of the operating system. The book succeeds because it augments this information with lucid explanations and many examples.

The primary focus of *Advanced MS-DOS*, despite its title, is not on the generic MS-DOS machine, but on the IBM PC family. The IBM PC BIOS services and the Lotus/Intel/Microsoft Expanded Memory Specification (LIM EMS) are covered in the book even though they are not part of DOS.

Other topics include: character I/O devices (keyboard video, printer, serial port); "well-behaved" versus high-performance but nonportable programming; record and file I/O; logical and physical disk organization; memory allocation; the EXEC function; interrupt handlers; device drivers; and filters.

The first 13 chapters describe the structure and functioning of the operating system. A brief history of DOS is followed by excellent descriptions of its component parts, how they are loaded and initialized, and how user programs are loaded. The explanation of .COM and .EXE files, and the differences between them are the most comprehensive and informative given in any source to date.

The descriptions of the DOS services are organized functionally rather than numerically. Similar functions are compared and contrasted, and the pros and cons of using one over another are discussed. Most valuable of all are the many examples in assembly language and C code. Some of these are complete and functional programs; others are code fragments for incorporation into the reader's programs; and still others are templates that need to be fleshed out for particular applications. A disk containing these examples in source code is available separately.

In many cases, the information presented in the book is not readily available in system documentation or from other sources. For example, the console I/O functions are tabulated to clarify the characteristics of each one and the differences between them. Device drivers and filters are explained in detail with comprehensive example programs. The chapter on memory allocation gives more information than any of the official sources. It still does not do full justice to the subject, but the author implies (as he does in several other places) that he is limited to presenting what Microsoft wants to make public.

The last third of the book is a reference manual for DOS interrupts and functions, the services provided by the PC's ROM BIOS, and the interface between the expanded memory manager and application programs. This section is organized in numerical sequence and, at least for the DOS and expanded memory functions, it presents basically the same information as the documentation that comes with MS-DOS. The one improvement is that the use of each function is illustrated by a fragment of assembly language code. For the BIOS functions, which are formally documented only in commented assembly language listings, the presentation in the same format as the DOS functions is a major convenience.

Only a few minor errors were found in the text. The most serious is in the description of buffered keyboard input (interrupt 21H, function 0AH), where it is stated that non-ASCII keys insert a two-byte scan code into the input buffer. In fact, such keys (except for the few function keys that perform the limited editing functions during input) are ignored by MS-DOS.

No document is perfect, and this book has several failings. The first is typical of most books in this fast-moving field: a measure of obsolescence. Although DOS 3.2 is mentioned as the latest version, its new functions are not covered. More significantly, the section on video output treats only the IBM Color Graphics Adapter and the monochrome adapter; it mentions the IBM Enhanced Graphics Adapter (EGA) only in passing. The EGA BIOS functions are not described or documented at all.

The book has two significant omissions. First, a substantive discussion of the environment block that is allocated for each program and of the potential uses of environment strings and other information in the block is not given. Second, the capabilities and uses of the ANSI.SYS driver, an integral part of DOS, are not covered. These omissions preclude using this book as a total replacement for the *DOS Technical Reference* manual. This is unfortunate because for the subjects it does cover, it is so much better than that volume, and at one-fifth the price.

—TED MIRECKI

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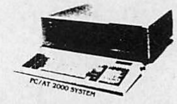

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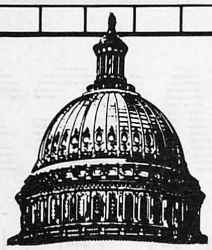

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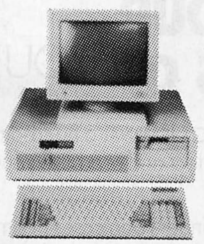

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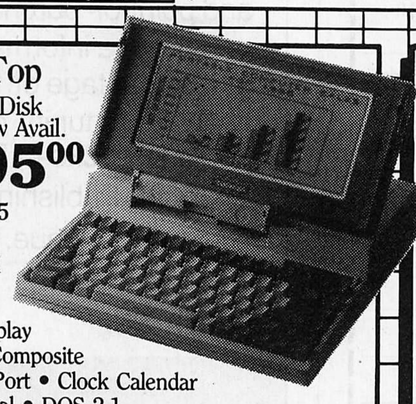

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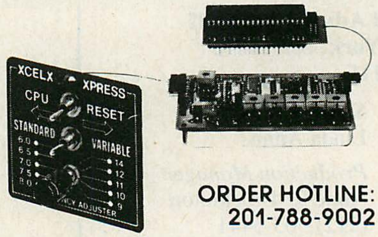

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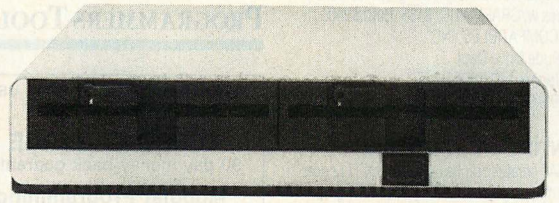

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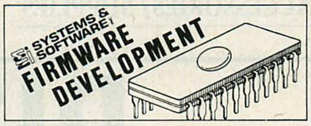

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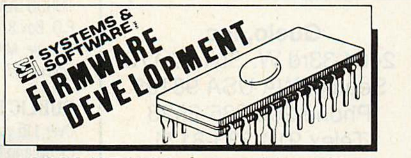

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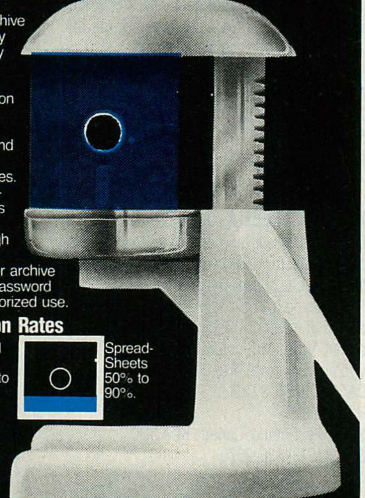

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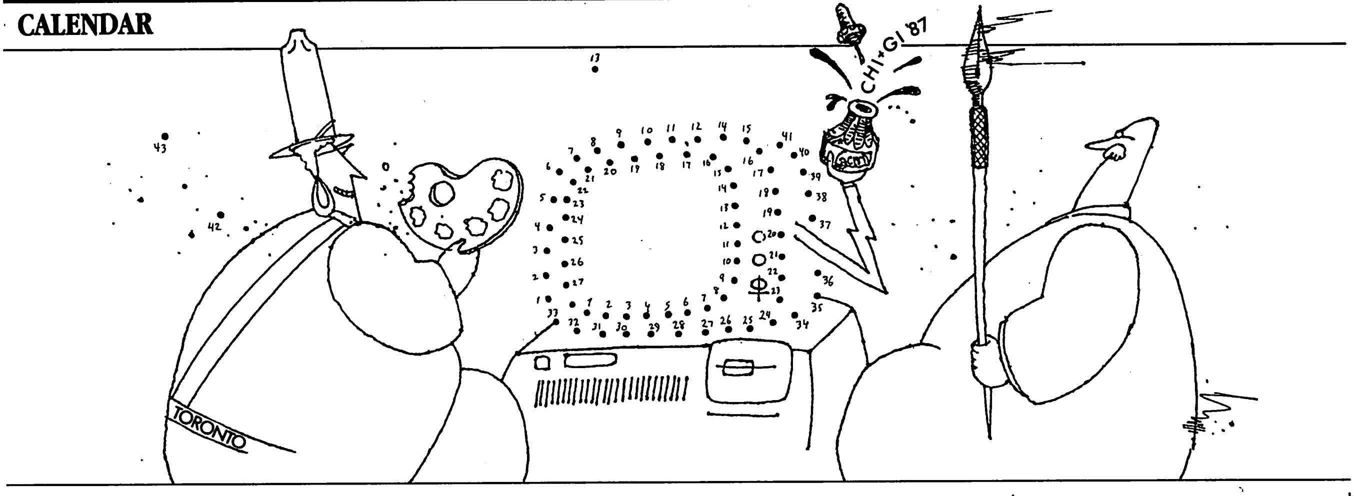

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April 20–24
Complexity of Approximately Solved Problems
New York, NY
Sponsor: Computer Sciences at Columbia University
Contact: Susan Maser, 450 Computer Science Building, Columbia University, New York, NY 10027; 212/280-8832

April 27–29
Symposium on Security and Privacy
Oakland, CA
Sponsors: IEEE-CS and IACR
Contact: Virgil D. Gligor, General Chairman, Department of Electrical Engineering, University of Maryland, College Park, MD 20742; 301/454-8846

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May 10–14
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May 11–13
Application-Specific Integrated Circuits
Cherry Hill, NJ
Sponsor: IEEE
Contact: Workstation Technology and Systems Workshop, 12 Colburn Drive, Poughkeepsie, NY 12603; 914/435-8185

May 11–13
Desktop Publishing '87
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CompEuro '87: VLSI and Computers
Hamburg, West Germany
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May 13–15
History of Scientific and Numeric Computation
Princeton, NJ
Sponsors: ACM and Society for Industrial and Applied Mathematics
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May 20
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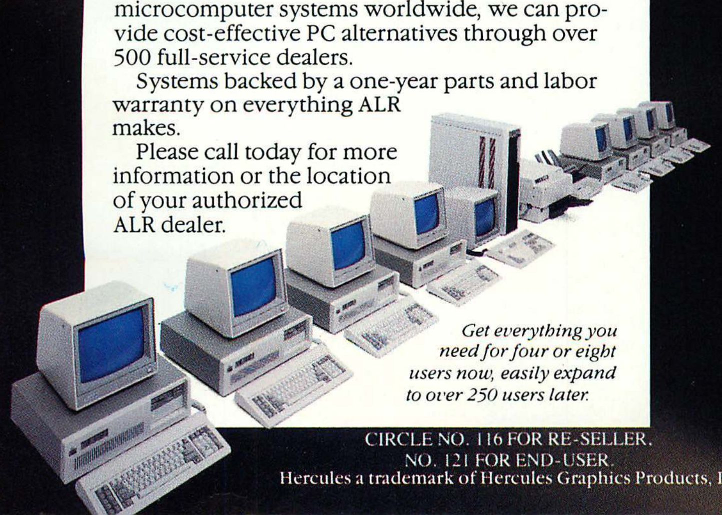

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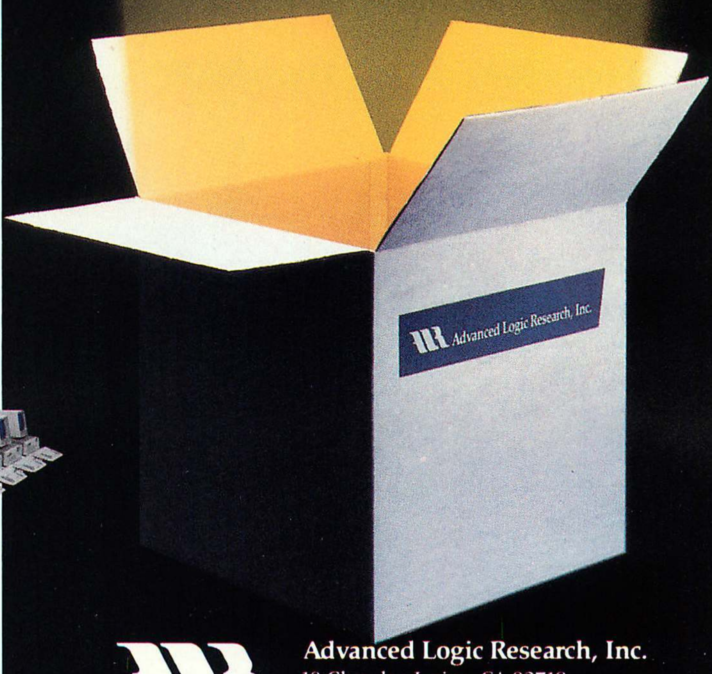

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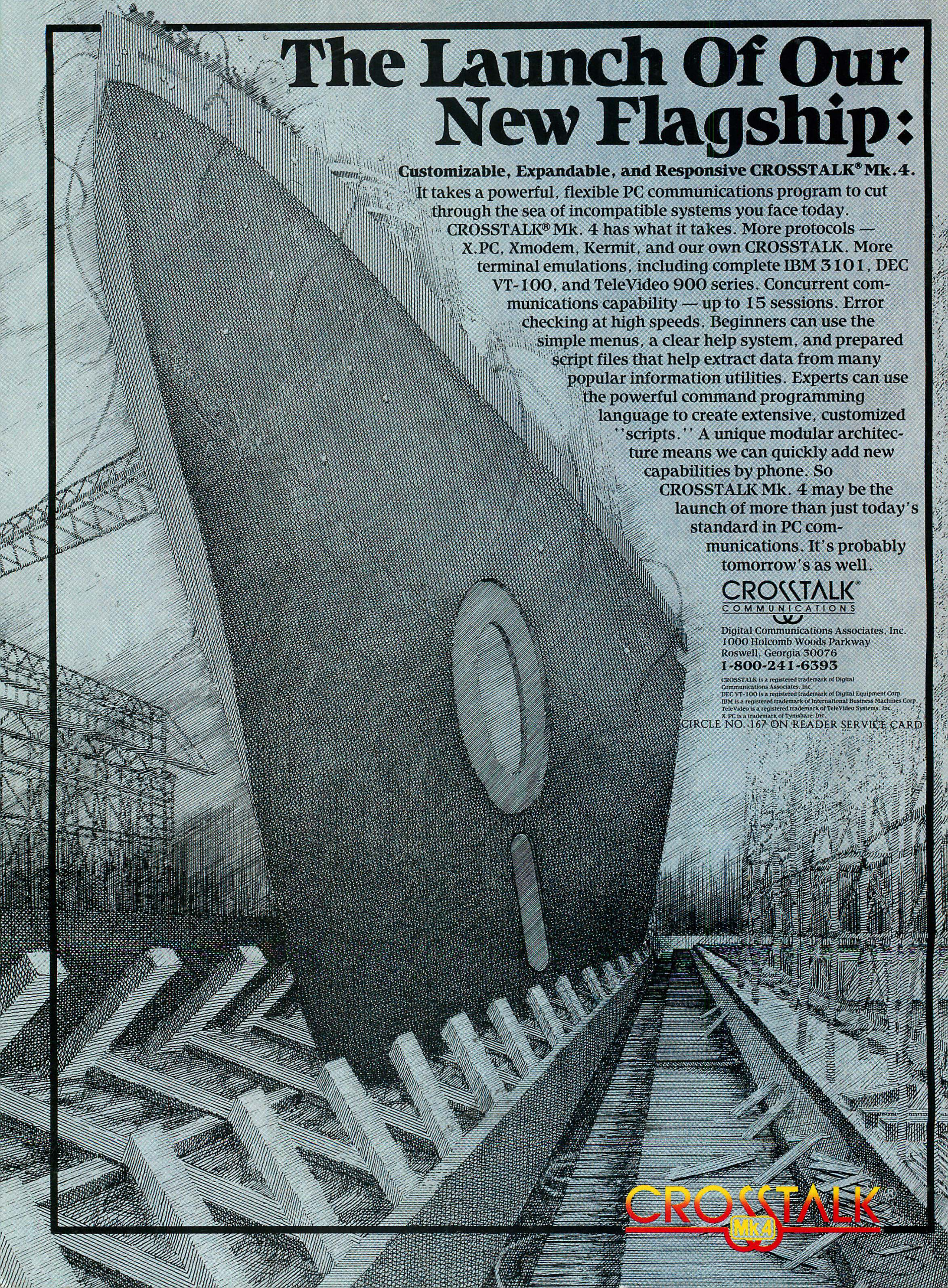
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